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Ambient Water Quality Criteria Recommendations

Information Supporting the Development of State and Tribal Nutrient Criteria

Lakes and Reservoirs in Nutrient Ecoregion X

EPA-822-R-02-051

AMBIENT WATER QUALITY CRITERIA RECOMMENDATIONS

INFORMATION SUPPORTING THE DEVELOPMENT OF STATE AND TRIBAL NUTRIENT CRITERIA

FOR

LAKES AND RESERVOIRS IN NUTRIENT ECOREGION X

Texas-Louisiana Coastal and Mississippi Alluvial Plains

including all or parts of the States of:

Texas, Louisiana, Mississippi, Arkansas, Tennessee, Kentucky, Missouri, and Illinois,

and the authorized Tribes within the Ecoregion

U.S. ENVIRONMENTAL PROTECTION AGENCY

OFFICE OF WATER
OFFICE OF SCIENCE AND TECHNOLOGY
HEALTH AND ECOLOGICAL CRITERIA DIVISION
WASHINGTON, DC

SEPTEMBER 2002

FOREWORD

This document presents EPA's nutrient criteria for **Lakes and Reservoirs in Nutrient Ecoregion X**. These criteria provide EPA's recommendations to States and authorized Tribes for use in establishing their water quality standards consistent with section 303(c) of the Clean Water Act (CWA). Under section 303(c) of the CWA, States and authorized Tribes have the primary responsibility for adopting water quality standards as part of State or Tribal law or regulation. Federal regulations require State and Tribal standards to contain scientifically defensible water quality criteria that are protective of designated uses. EPA's recommended section 304(a) criteria are not laws or regulations; they are guidance that States and Tribes may use as a starting point in creating their own water quality standards.

The term "water quality criteria" is used in two sections of the CWA, section 304(a)(1) and section 303(c)(2). The term has a different impact in each section. On the one hand, in section 304, the term represents a scientific assessment of ecological and human health effects that EPA recommends to States and authorized Tribes for establishing water quality standards that ultimately provide a basis for controlling discharges or releases of pollutants or related parameters. On the other hand, in section 303, ambient water quality criteria are developed by States and Tribes as part of their water quality standards, to define the level of a pollutant (or in the case of nutrients, a condition) necessary to protect designated uses in ambient waters.

Quantified water quality criteria contained within State or Tribal water quality standards are essential to a water quality-based approach to pollution control. Whether expressed numerically or as quantified translations of narrative criteria within State or Tribal water quality standards, quantified criteria are critical for assessing attainment of designated uses and measuring progress toward meeting CWA goals.

EPA is developing section 304(a) water quality criteria for nutrients because States and Tribes consistently identify excessive levels of nutrients as a major reason that as many as half of the Nation's surface waters surveyed do not meet water quality objectives, such as full support of aquatic life. EPA expects to develop nutrient criteria that cover four major types of waterbodies—lakes and reservoirs, rivers and streams, estuarine and coastal areas, and wetlands—across 14 major Ecoregions of the United States. EPA's section 304(a) criteria are intended to provide for the protection and propagation of aquatic life and recreation. To support the development of nutrient criteria, EPA has published and will continue to publish technical guidance manuals that describe a process for assessing nutrient conditions in the four waterbody types listed above.

EPA's section 304(a) water quality criteria for nutrients provide numeric water quality criteria and procedures to help establish quantified criteria within State or Tribal water quality standards. In the case of nutrients, EPA section 304(a) criteria establish values for causal variables (e.g., total nitrogen and total phosphorus) and response variables (e.g., Secchi depth and chlorophyll *a*). EPA believes that State and Tribal water quality standards need to include quantified endpoints for causal and response variables to provide sufficient protection of uses and to maintain downstream uses. These endpoints will most often be expressed as numeric water quality criteria or as procedures to translate a State or Tribal narrative criterion into a quantified endpoint.

States and authorized Tribes have several options in adopting these criteria. EPA recommends the following approaches, in order of preference:

1. Wherever possible, develop nutrient criteria that fully reflect local conditions and protect specific designated uses through the process described in EPA's technical guidance manuals for nutrient criteria development. Such criteria may be expressed either as numeric criteria or as procedures to translate a State or Tribal narrative criterion into a quantified endpoint in State or Tribal water quality standards.

2. Adopt EPA's section 304(a) water quality criteria for nutrients, either as numeric criteria or as procedures to translate a State or Tribal narrative nutrient criterion into a quantified endpoint.

3. Develop nutrient criteria protective of designated uses using other scientifically defensible methods and appropriate water quality data.

EPA developed the nutrient criteria recommendations in this document with the intent that they serve as a starting point for States and Tribes to develop more refined criteria, as appropriate, to reflect local conditions. The values presented in this document generally represent nutrient levels that protect against the adverse effects of nutrient overenrichment. They are based on the information that was available to the Agency at the time of this publication. EPA expects States and Tribes may have additional information and data that may be utilized in the refinement of these criteria. EPA offers to work with States and authorized Tribes to establish the necessary quantitative endpoints to reduce the excess nutrient inputs into our nation's waters and to prevent any further impairments.

Geoffrey H. Grubbs, Director
Office of Science and Technology

DISCLAIMER

This document provides technical guidance and recommendations to States, authorized Tribes, and other authorized jurisdictions to develop water quality criteria and water quality standards under the Clean Water Act (CWA) to protect against the adverse effects of nutrient overenrichment. Under the CWA, States and authorized Tribes are to establish water quality criteria to protect designated uses. State and Tribal decisionmakers retain the discretion to adopt approaches on a case-by-case basis that differ from this guidance when appropriate and scientifically defensible. Even though this document contains EPA's scientific recommendations regarding ambient concentrations of nutrients that will protect aquatic resource quality, it does not substitute for the CWA or EPA regulations, nor is it a regulation itself. Thus it cannot impose legally binding requirements on EPA, States, authorized Tribes, or the regulated community, and it might not apply to a particular situation or circumstance. EPA may change this guidance in the future.

EXECUTIVE SUMMARY

Nutrient Program Goals

EPA developed the National Strategy for the Development of Regional Nutrient Criteria (National Strategy) in June 1998. The strategy presents EPA's intentions to develop technical guidance manuals for four types of waters (lakes and reservoirs, rivers and streams, estuaries and coastal waters, and wetlands) and produce section 304(a) criteria for specific nutrient Ecoregions by the end of 2000. In addition, the Agency formed Regional Technical Assistance Groups (RTAGs), which include State and Tribal representatives working to develop more refined and localized nutrient criteria based on approaches described in the waterbody guidance manuals. This document presents EPA's current recommended criteria for total phosphorus (TP), total nitrogen (TN), chlorophyll *a*, and Secchi for lakes and reservoirs in Nutrient Ecoregion X, which were derived using the procedures described in the *Lakes and Reservoirs Nutrient Criteria Technical Guidance Manual* (U.S. EPA, 2000a).

EPA's ecoregional nutrient criteria address cultural eutrophication—the adverse effects of excess human-caused nutrient inputs. The criteria are empirically derived to represent surface waters that are minimally impacted by human activities and protective of aquatic life and recreational uses. The information contained in this document represents starting points for States and Tribes to develop (with assistance from EPA) more refined nutrient criteria.

In developing these criteria recommendations, EPA followed a process that included, to the extent they were readily available, the following critical elements:

- **Historical and recent nutrient data in Nutrient Ecoregion X.** Data sets from Legacy STORET, NASQA, EPA Region 7 - Central Plains Center for BioAssessment (CPCB), EPA Region 7 - CPCB 2, and EPA Region 7 - REMAP were used to assess nutrient conditions from 1990 to 2000.

- **Reference sites/reference conditions in Nutrient Ecoregion X.** Reference conditions presented are based on 25th percentiles of all nutrient data, including a comparison of reference conditions for the Aggregate Ecoregion versus the subecoregions. States and Tribes are urged to determine their own reference sites for lakes and reservoirs at different geographic scales and to compare them to EPA's reference conditions.

- **Models employed for prediction or validation.** EPA did not identify any specific models to develop nutrient criteria. States and Tribes are encouraged to identify and apply appropriate models to support nutrient criteria development.

- **RTAG expert review and consensus.** EPA recommends that when States and Tribes prepare their nutrient criteria, they obtain the expert review and consent of the RTAG.

- **Downstream effects of criteria.** EPA encourages the RTAG to assess the potential effects of the proposed criteria on downstream water quality and uses.

In addition, EPA followed specific **QA/QC procedures** during data collection and analysis. All data were reviewed for duplications. All data were from ambient waters that were not located directly outside a permitted discharger. The following States indicated that their data were sampled and analyzed using either standard methods or EPA-approved methods: North Dakota, South Dakota, Montana, Wyoming, Colorado, Kansas, Oklahoma, and Texas. Nebraska indicated that standard or EPA-approved methods were used for some specific nutrient parameters.

The following tables contain a summary of aggregate and level III Ecoregion values for TN, TP, water column chlorophyll *a*, and Secchi.

BASED ON 25th PERCENTILES ONLY

Nutrient Parameters	Aggregate Nutrient Ecoregion X Reference Conditions
Total phosphorus (µg/L)	60
Total nitrogen (mg/L) (calculated)	0.57
Chlorophyll *a* (µg/L) (spectrophotometric method)	5.5
Secchi (m)	0.8

For subecoregions 34 and 73, the ranges of nutrient parameter reference conditions are as follows:

BASED ON 25th PERCENTILE ONLY

Nutrient Parameters	Range of Level III Subecoregions Reference Conditions
Total phosphorus (µg/L)	56.25–115.63
Total nitrogen (mg/L) (calculated)	0.55–0.74
Chlorophyll *a* (µg/L) (spectrophotometric method)	3.6–79.2
Secchi (m)	0.7–0.8

Note: In subecoregion 34, the data come from 10 sample stations on 5 lakes. The data for subecoregion 73 is based on 190 stations on 52 lakes.

NOTICE OF DOCUMENT AVAILABILITY

This document is available electronically to the public through the Internet at http://www.epa.gov/OST/standards/nutrient.html. Requests for hard copies of the document should be made to EPA's National Service Center for Environmental Publications (NSCEP), 11029 Kenwood Road, Cincinnati, OH 45242; telephone (513) 489-8190 or toll free (800) 490-9198. Please refer to EPA document number EPA-822-R-02-051.

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1.0 INTRODUCTION

Background

Nutrients are essential to the health and diversity of surface waters. However, in excessive amounts nutrients cause eutrophication or hypereutrophication, which results in overgrowth of plant life and decline of the biological community. Excessive nutrients can also result in human health risks, such as the growth of harmful algal blooms. Chronic nutrient overenrichment of a waterbody can lead to the following consequences: algal blooms, low dissolved oxygen, fish kills, overabundance of macrophytes, likely increased sedimentation, and species shifts of both flora and fauna.

Historically, National Water Quality Inventories have repeatedly shown that nutrients are a major cause of ambient water quality use impairments. EPA's 1996 National Water Quality Inventory report identifies excessive nutrients as the leading cause of impairment in lakes and the second leading cause of impairment in rivers (behind siltation). In addition, nutrients were the second leading cause of impairments after siltation reported by the States in their 1998 lists of impaired waters. Where use impairment is documented, nutrients contribute roughly 25%-50% of the impairment nationally. The Clean Water Act (CWA) establishes that, wherever possible, water quality must provide for the protection and propagation of fish, shellfish, and wildlife, and recreation in and on the water and/or protecting the physical, chemical, and biological integrity of those waters. In adopting water quality standards, States and Tribes designate uses for their waters in consideration of these CWA goals, and establish water quality criteria that contain sufficient parameters to protect that integrity and those uses. To date, EPA has not published information and recommendations under section 304(a) for nutrients to assist States and Tribes in establishing numeric nutrient criteria to protect uses when adopting water quality standards.

In 1995, EPA gathered a set of national experts and asked them how best to deal with the national nutrient problem. The experts recommended that the Agency not develop single criteria values for phosphorus (P) or nitrogen (N) applicable to all waterbodies and regions of the country. Rather, they recommended that EPA put a premium on regionalization, develop guidance (assessment tools and control measures) for specific waterbodies and ecological regions across the country, and use reference conditions (conditions that reflect pristine or minimally impacted waters) as a basis for developing nutrient criteria.

With these suggestions as starting points, EPA developed the National Strategy for the Development of Regional Nutrient Criteria (National Strategy), published in June 1998. This strategy presented EPA's intentions to develop technical guidance manuals for four types of waters (lakes and reservoirs, rivers and streams, estuaries and coastal waters, and wetlands), and thereafter to publish section 304(a) criteria recommendations for specific nutrient Ecoregions. Technical guidance manuals for lakes/reservoirs and rivers/streams were published in April 2000 and July 2000, respectively. The technical guidance manual for estuaries/coastal waters was published in fall 2001, and the draft wetlands technical guidance manual will be published by December 2001. Each manual presents EPA's recommended approach for developing nutrient criteria values for a specific waterbody type. In addition, EPA is committed to working with

States and Tribes to develop more refined and localized nutrient criteria based on approaches described in the waterbody guidance manuals and this document.

Overview of the Nutrient Criteria Development Process

For each nutrient Ecoregion, EPA developed a set of recommendations for two causal variables (total nitrogen and total phosphorus) and two early indicator response variables (chlorophyll *a* [chl *a*] and Secchi). Other indicators such as dissolved oxygen, macrophyte or benthic algal growth or speciation, and other fauna and flora changes are also useful. However, the first four variables are considered to be the best suited for protecting designated uses.

The technical guidance manuals describe a process for developing nutrient criteria that involves consideration of five factors. The first of these is the Regional Technical Assistance Group (RTAG), which is a body of qualified regional specialists able to objectively evaluate all of the available evidence and select the value(s) appropriate to nutrient control in the water bodies of concern. These specialists may come from such disciplines as limnology, biology, or natural resources management—especially water resource management, chemistry, and ecology. The RTAG evaluates and recommends appropriate classification techniques, usually physical, for criteria determination within an ecoregional construct.

The second factor is the historical information available to establish a perspective of the resource base. This is usually data and anecdotal information available within the past 10-25 years. This information gives evidence about the background and enrichment trend of the resource.

The third factor is the existing reference condition, a selection of reference sites chosen to represent the least culturally impacted waters of the class at the present time. The data from these sites are combined and a value is selected to represent the reference condition, the best attainable, most natural condition of the resource base at this time.

The RTAG comprehensively evaluates these three elements to propose a candidate criterion (initially one each for TP, TN, chl *a*, and Secchi).

A fourth factor often employed is mechanistic or empirical models of the historical and reference condition data to better understand the condition of the resource.

The final element of the process is assessment by the RTAG of the likely downstream effects of the criterion. Will there be a negative, positive, or neutral effect on the downstream waterbody? If the RTAG judges that a negative effect is likely, then the proposed State/Tribal water quality criteria should be revised to ameliorate the potential for any adverse downstream effects.

Although States and authorized Tribes do not necessarily need to incorporate all five elements into their water quality criteria setting process (e.g., modeling may be significant in only some instances), the best assurance of a representative and effective criterion is a balanced incorporation of all five elements.

Because some parts of the country have naturally different soil and parent material nutrient content, and different precipitation regimes, the application of the criterion development process should reflect this regional variation. Therefore, an ecoregional approach was chosen. Initially, the continental United States was divided into 14 separate Ecoregions of similar geographical characteristics and similar nutrient condition (Figure 1a). Ecoregions are defined as regions of relative homogeneity in ecological systems; they depict areas within which the mosaic of ecosystem components (biotic and abiotic as well as terrestrial and aquatic) is different from adjacent areas in a holistic sense. Geographic characteristics such as soils, vegetation, climate, geology, and land cover are relatively similar within each Ecoregion (Omernik, 2000).

The nutrient Ecoregions are aggregates of EPA's hierarchical level III Ecoregions (see Figure 1b for a map of level III Ecoregions). As such, they are more generalized and less defined than level III Ecoregions. EPA determined that setting ecoregional criteria for the large-scale aggregates is not without its drawbacks: variability is high because of the lumping of many waterbody classes, seasons, and years worth of multipurpose data over a large geographic area. For these reasons, the Agency recommends that States and Tribes develop nutrient criteria at the level III ecoregional scale and at the waterbody-class scale, where those data are readily available. Data analyses and recommendations on both the large Aggregate Ecoregion scale and the more refined scales (level III Ecoregions and waterbody classes), where data were available to make such assessments, are presented for comparison and completeness of analysis.

Comparison of Nutrient Criteria to Biological Criteria

Biological criteria are quantitative expressions of the desired condition of the aquatic community. Such criteria can be based on data from sites that represent the least impacted attainable condition for a particular waterbody type in an Ecoregion, subecoregion, or watershed. EPA's nutrient criteria recommendations and biological criteria recommendations have many similarities in their basic approaches to development and data requirements. Both are empirically derived from statistical analysis of field-collected data and expert evaluation of current reference conditions and historical information. Both use direct measurements from the environment to integrate the effects of complex processes that vary according to type and location of waterbody. The resulting criteria recommendations, in both cases, are efficient uses of existing resources and are holistic indicators of the water quality necessary to protect uses.

States and authorized Tribes can develop and apply nutrient and biological criteria in tandem, with each providing important and useful information to interpret both the nutrient enrichment levels and the biological condition of sampled waterbodies. For example, using the same reference sites for both types of criteria can lead to efficiencies in both sample design and data analysis. In one effort, environmental managers can obtain information to support assessment of biological and nutrient condition, either through evaluating existing data sets or through designing and conducting a common sampling program. The traditional biological criteria variables of benthic invertebrate and fish sampling can be readily incorporated in a nutrient assessment. To investigate the effectiveness of this tandem approach, EPA has initiated pilot projects in both freshwater and marine environments to pursue the relationship between nutrient overenrichment and apparent declines in diversity of benthic invertebrates and fish.

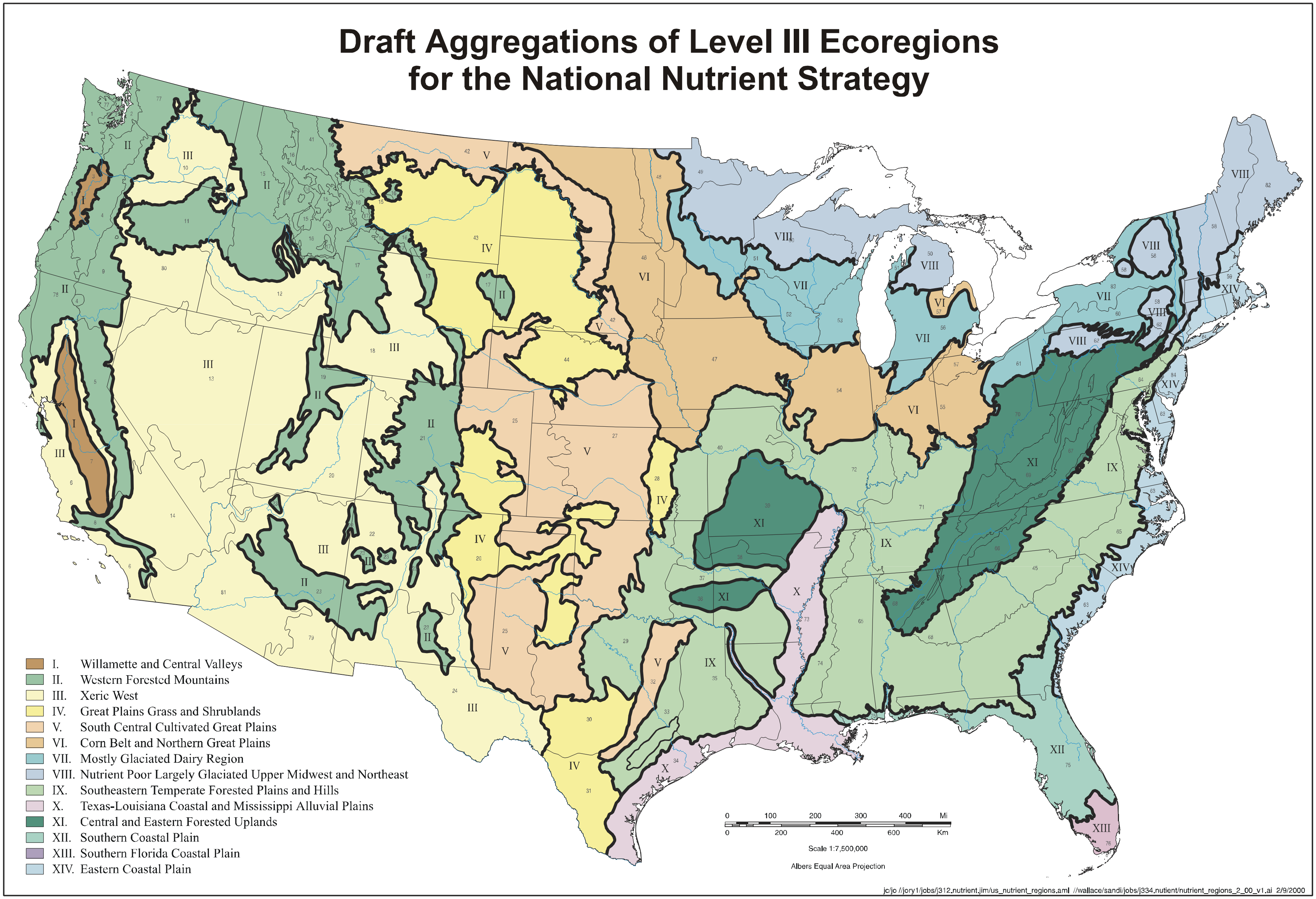


Figure 1a. Fourteen nutrient Ecoregions as delineated by Omernik (2000). Ecoregions were based on geology, land use, ecosystem type, and nutrient conditions.

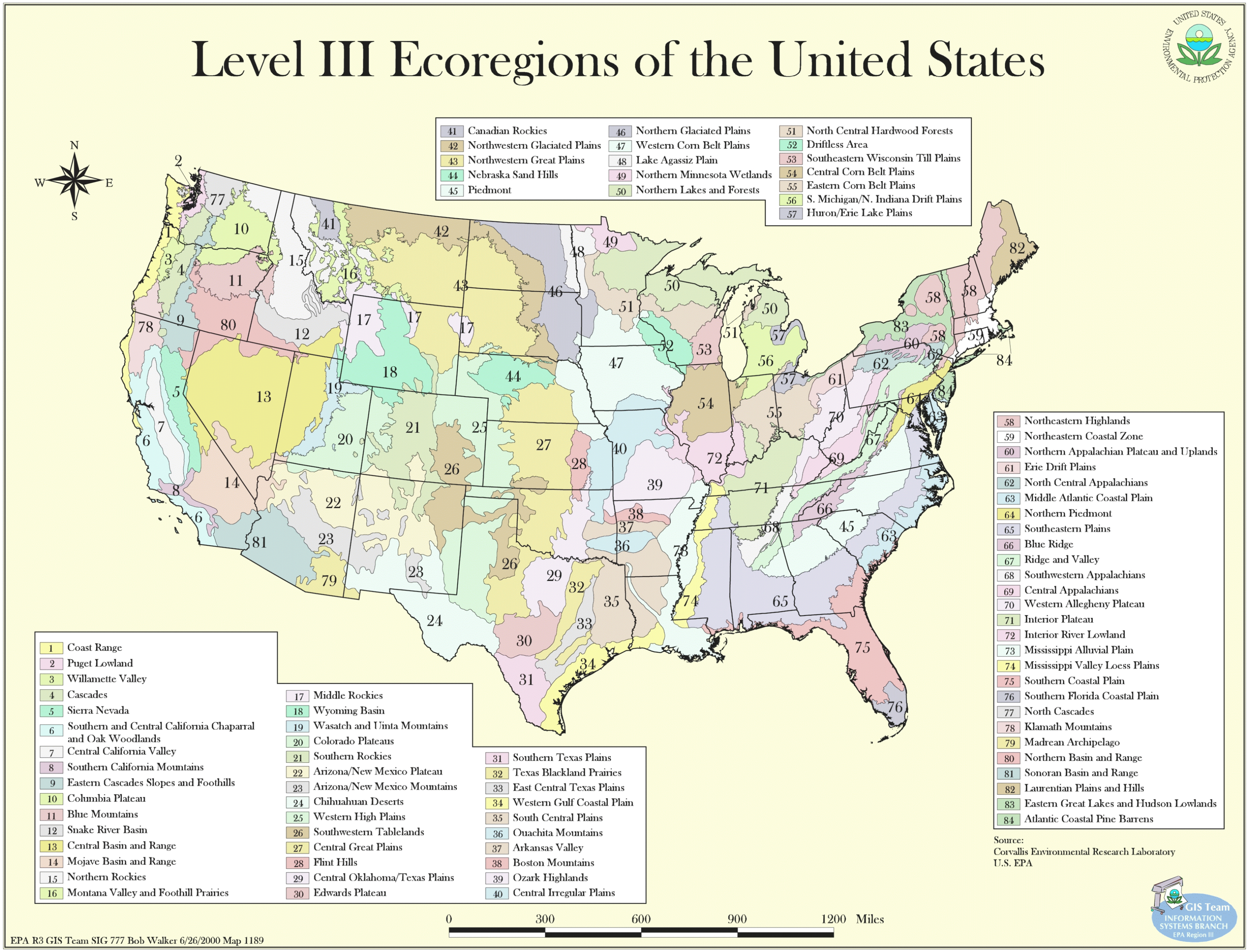


Figure 1b. Level III Ecoregions of the United States.

2.0 BEST USE OF THIS INFORMATION

EPA recommendations published under section 304(a) of the CWA serve several purposes, including providing guidance to States and Tribes in adopting water quality standards for nutrients and ultimately controlling discharges or releases of pollutants. The recommendations also provide guidance to EPA when it determines that it is necessary to promulgate Federal water quality standards under section 303(c). Other uses include identification of overenrichment problems, management planning, project evaluation, and determination of status and trends of water resources.

State water quality inventories and listings of impaired waters consistently rank nutrient overenrichment as a top contributor to use impairments. EPA's water quality standards regulations at 40 CFR §131.11(a) require States and Tribes to adopt criteria that contain sufficient parameters and constituents to protect the designated uses of their waters. In addition, States and Tribes need quantifiable targets for nutrients to assess attainment of uses, develop water quality-based permit limits and source control plans, and establish targets for total maximum daily loads (TMDLs).

EPA expects States and Tribes to address nutrient overenrichment in their water quality standards and to build on existing State and Tribal efforts where possible. States and Tribes can address nutrient overenrichment through establishment of numerical criteria or use of narrative criteria statements (e.g., "free from excess nutrients that cause or contribute to undesirable or nuisance aquatic life or produce adverse physiological response in humans, animals, or plants"). In the case of narrative criteria, EPA expects that States and Tribes will establish procedures to quantitatively translate these statements for both assessment and source control purposes.

Ecoregional nutrient criteria are developed to represent surface waters that are minimally impacted by human activities and thus protect against the adverse effects of nutrient overenrichment from cultural eutrophication. EPA's recommended process for developing such criteria includes physical classification of waterbodies, determination of current reference conditions, evaluation of historical data and other information (such as published literature), use of models to simulate physical and ecological processes or determine empirical relationships among causal and response variables (if necessary), expert judgment, and evaluation of downstream effects. EPA has used elements of this process to produce the information contained in this document. The causal (total nitrogen, total phosphorus) and biological and physical response (chlorophyll *a*, Secchi) variables represent a set of starting points for States and Tribes to use in establishing their own criteria.

EPA recommends that States and Tribes establish numerical criteria based on section 304(a) guidance, section 304(a) guidance modified to reflect site-specific conditions, or other scientifically defensible methods. For many pollutants, such as toxic chemicals, EPA expects that section 304(a) guidance will provide an appropriate level of protection without further modification. EPA has also published methods for modifying 304(a) criteria, such as the water effect ratio, on a site-specific basis where conditions warrant modification to achieve the intended level of protection. For nutrients, however, EPA expects that it will usually be necessary for States and authorized Tribes to be more precise in identifying the nutrient levels that protect aquatic life and recreational uses. This can be achieved through criteria modified to reflect a smaller geographic scale than an Ecoregion, such as a subecoregion, the State or Tribe level, or a specific class of waterbodies. Criteria can be refined by grouping data or performing analyses at these smaller geographic scales. Refinement can also occur through further consideration of other elements such as published literature or models.

EPA expects that the values presented in this document generally represent nutrient levels that protect against the adverse effects of cultural overenrichment and are based on information available to the Agency at the time of this publication. However, States and Tribes should critically evaluate this information in light of the specific uses that need to be protected. For example, more sensitive uses may require more stringent criteria to ensure adequate protection. On the other hand, overly stringent levels of protection against cultural eutrophication may actually fall below the natural load of nutrients for certain waterbodies. In cases such as these, the level of nutrients specified may not be sufficient to support a productive fishery. In the criteria derivation process, it is important to distinguish between the natural load associated with a specific waterbody using historical data and expert judgment and current reference conditions. These elements of the criteria derivation process are best addressed by States and Tribes with access to information and local expertise. Therefore, EPA strongly encourages States and Tribes to use the information contained in this document to develop more refined criteria according to the methods described in EPA's technical guidance manuals for specific waterbody types.

To assist in further refinement of nutrient criteria, EPA has established 10 RTAGs (experts from EPA Regional Offices and States/Tribes). In refining criteria, States and authorized Tribes need to provide documentation of data and analyses, along with a defensible rationale, for any new or revised nutrient criteria they submit to EPA for review and approval. As part of EPA's review of State and Tribal standards, EPA intends to seek assurance from the RTAG that proposed criteria are sufficient to protect uses.

In using the information and recommendations in this document and elsewhere to develop numerical criteria or procedures to translate narrative criteria, EPA encourages States and Tribes to:

- Address both chemical causal variables and early indicator response variables. Causal variables are necessary to protect uses before impairment occurs and to maintain downstream uses. Early response variables are necessary to warn of possible impairment and to integrate the effects of variable and potentially unmeasured nutrient loads.

- Include variables that can be measured to determine if standards are met, and variables that can be related to the ultimate sources of excess nutrients.

- Identify appropriate periods of duration (how long) and frequency (how often) of occurrence in addition to magnitude (how much). EPA does not recommend identifying nutrient concentrations that must be met at all times; rather a seasonal or annual averaging period (e.g., based on weekly or biweekly measurements) is considered appropriate. However, these central tendency measures should apply each season or each year, except under the most extraordinary conditions (e.g., a 100-year flood).

3.0 AREA COVERED BY THIS DOCUMENT

This chapter provides a general description of the Aggregate Ecoregion and its geographical boundaries. Descriptions of the level III subecoregions contained within the Aggregate Ecoregion are also provided.

3.1 Description of Aggregate Ecoregion X

Ecoregion X is nearly level and is composed of alluvial plains in the Mississippi River Valley and coastal plains along the Gulf of Mexico. It is well known for producing large amounts of cotton and rice and has concentrations of industrial and urban activity. The Mississippi alluvial plain has nutrient-rich soils, a favorable climate, and is one of the most important cash crop areas in the United States; soils in the more irregular Southeastern Temperate Forested Plains and Hills (IX) are not as naturally fertile. The coastal plain is dominated by range, pasture, marshy wildlife habitat, woodland, cropland, and both recreational and urban development. Cotton, soybeans, rice, sorghum, corn, sugarcane, hay, and wheat are grown in Ecoregion X. A higher percentage of the land is in cropland than in bordering nutrient Ecoregions. Wet soils are common and must be artificially drained to be farmed. The wettest areas that are not artificially drained remain in forests and wetlands and are important wildlife habitat. Urban and industrial areas are found in the region and population is increasing. Urbanization, industrial activity, and agricultural runoff have affected the region's water quality.

The Mississippi River Valley portion of Ecoregion X extends from its junction with the Ohio River to the Mississippi Delta. It is mostly a broad, flat floodplain that contains many oxbow lakes and bayous; it is physiographically distinct from the neighboring Southeastern Temperate Forested Plains and Hills (IX) and the Central and Eastern Forested Uplands (XI). River terraces and levees provide the main elements of relief. Winters are mild, summers are hot, and both temperature and precipitation increase from north to south. The mean annual temperature is very warm, freeze-free growing season is long, and mean annual precipitation is plentiful and are, respectively, 57-70°F, 200-340 days, and 45-65 inches. Soils are nutrient-rich and have a thermic temperature regime and an aquic or udic moisture regime. The potential natural vegetation of the Mississippi River Valley is mostly southern floodplain forest (dominants: tupelo, oak, bald cypress) with some areas of oak-hickory forest mixed in; southern cordgrass prairie is found on the outer Mississippi Delta. Most of the original bottomland deciduous forest has been cleared and drained for cultivation and, today, the Valley is an important agricultural area. Overall, about 55% of the Mississippi River Valley portion of Ecoregion X is used as cropland, 35% is used as woodland, and 7% is used as pastureland. Cropland comprises about 75% of the north but, in the south, pasture, woodland, forest, marshland, and swamp are more common. The Valley's favorable climate and its productive, nutrient-rich soils support soybean, cotton, rice, sorghum, corn, hay, wheat, and, in Louisiana, sugarcane farming; land in cotton increased by almost a million acres between 1987 and 1992, by far the largest such increase in the United States. Most of the northern and central parts of the region receive heavy treatments of insecticides, herbicides, and fertilizers and have a high potential for pesticide, phosphate fertilizer, and nitrogen fertilizer runoff. Soils are poorly-drained and must be artificially drained to be farmed. Controlling surface water is a major concern of management. Agricultural runoff containing fertilizers, herbicides, pesticides, and livestock waste and channelization have affected surficial water quality. Total phosphorus, total ammonia, and nitrite plus nitrate concentrations are often high in rivers, streams, and ditches due to extensive fertilizer use and discharge from municipal sewage treatment plants (U.S. Geological Survey, 1993). Turbidity is a problem in channelized areas. Pesticide residues are found in the surface waters (USGS, 1993).

The coastal plain portion of Ecoregion X extends westward from the Mississippi River Delta to Brownsville, Texas along the Gulf of Mexico. It is comprised of nearly level coastal lowlands with barrier islands, bays, marshes, and some low dunes in sandy areas. Elevations typically range from sea level to 150 feet but, in some areas, they reach 325 feet. Lowest parts of the area are marshy and are covered by high tides and storm tides. Farther inland, are the higher and more irregular plains of Ecoregions IV, V, and IX. Winters are mild, summers are hot, and precipitation increases from west to east. The mean annual temperature is very warm, freeze-free growing season is long, and mean annual precipitation is plentiful and are, respectively, 66-73°F, 250-350 days, and 25-60 inches. The potential natural vegetation is sea oats prairie on barrier islands, southern cordgrass prairie in the near-shore zone, and seacoast bluestem-coastal sacahuista prairie in higher areas away from the coast to an elevation of about 150 feet; farther inland in eastern Texas and western Louisiana, pine-hardwood forest is mapped to about 325 feet elevation sweetgum, blackgum, post oak, blackjack oak, and southern red oak] and both mesquite-live oak savanna and mesquite-acacia savanna occur in drier areas of southern Texas. Today, near shore areas are mostly native rangeland and wildlife habitat; in addition, there is expanding urban and recreation development especially along the barrier beaches but freshwater is limited and often must be piped in. Farther inland, land-use changes. On the former seacoast bluestem-coastal sacahuista prairie, about 40% of the acreage is now cropland producing rice, soybeans, grain sorghum, cotton, corn, and hay, 30% is range or pasture, and hardwood forest borders the rivers and streams; locally, urban development is rapidly expanding onto agricultural land. Most soils are artificially drained for general farm crops and rice is irrigated from streams and wells. In eastern Texas and western Louisiana, about 75% remains in pine-hardwood forest and produces lumber and pulpwood; the remainder is mostly used as pasture or as sites for small subdivisions. Present-day land use significantly impacts surface and subsurface water quality. Elevated concentrations of nitrate and phosphorus are significant water quality problems in many basins and can be a byproduct of agricultural runoff. Dissolved oxygen depletion has occurred in some sluggish, warm rivers affected by nutrient-laden agricultural runoff. Sulfate concentrations are locally high where streams are impacted by industrial activity but are usually lower than in nutrient regions underlain by gypsum or salt beds. Urban runoff, municipal wastewater effluent, and livestock impact the level of nutrient and fecal coliform bacteria in streams and rivers. Industrial activity has released contaminants including heavy metals to surface waters. In addition, groundwater overdraft has caused saline intrusion into fresh water aquifers.

3.2 Geographical Boundaries of Aggregate Ecoregion X

The northern boundary of Ecoregion X begins along the borders of Illinois, Missouri, and Kentucky at the junction of the Ohio River and Mississippi River (Figure 2). The region continues south along the Mississippi River Valley, encompassing portions of Missouri, Tennessee, Arkansas, Mississippi, and Louisiana.

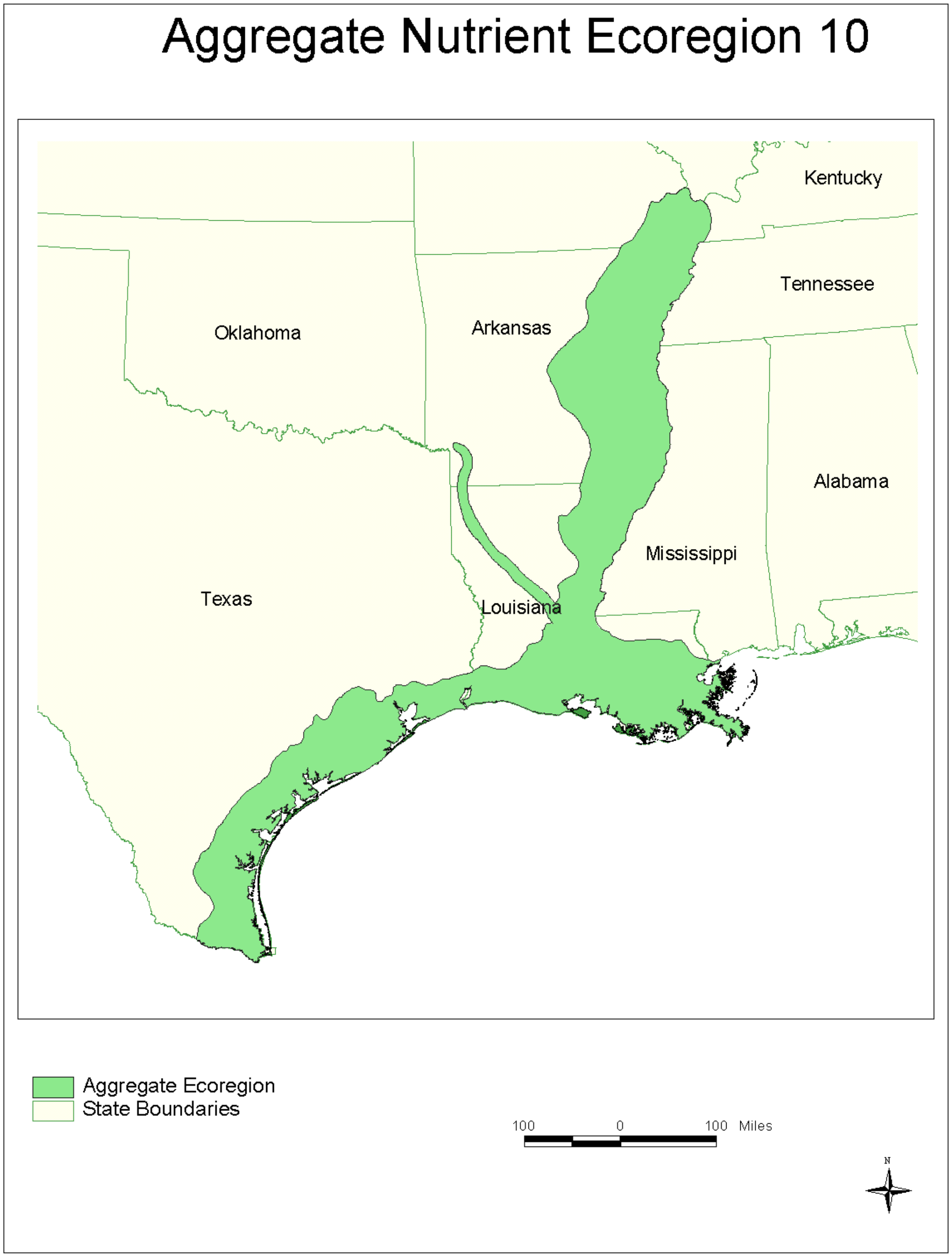


Figure 2. Aggregate Ecoregion X.

At the junction of the Mississippi River and Red River, the region continues northwest up the Red River through Louisiana and into Arkansas.

The coastal plain portion of Ecoregion X extends westward from the Mississippi River Delta along the Gulf of Mexico through Louisiana and down to the southern tip of Texas.

3.3 Level III Subecoregions Within Aggregate Ecoregion X

There are two level III subecoregions contained within Aggregate Ecoregion X (Figure 3). The following are brief descriptions provided by Omernik (1999) of the climate, vegetative cover, topography, and other ecological information pertaining to these subecoregions.

34. Western Gulf Coastal Plain

The principal distinguishing characteristics of the Western Gulf Coastal Plain are its relatively flat coastal plain topography and mainly grassland potential natural vegetation. Inland from this region the plains are more irregular and have mostly forest or savanna-type vegetation potentials. Largely because of these characteristics, a higher percentage of the land is in cropland than in bordering ecological regions. Recent urbanization and industrialization have become concerns in this region.

73. Mississippi Alluvial Plain

This riverine Ecoregion extends from southern Illinois, at the confluence of the Ohio River with the Mississippi River, south to the Gulf of Mexico. It is mostly a flat, broad floodplain with river terraces and levees providing the main elements of relief. Soils tend to be poorly drained, except for the areas of sandy soils. Winters are mild and summers are hot, with temperatures and precipitation increasing from north to south. Bottomland deciduous forest vegetation covered the region before much of it was cleared for cultivation. Presently, most of the northern and central parts of the region are in cropland and receive heavy treatments of insecticides and herbicides. Soybeans, cotton, and rice are the major crops.

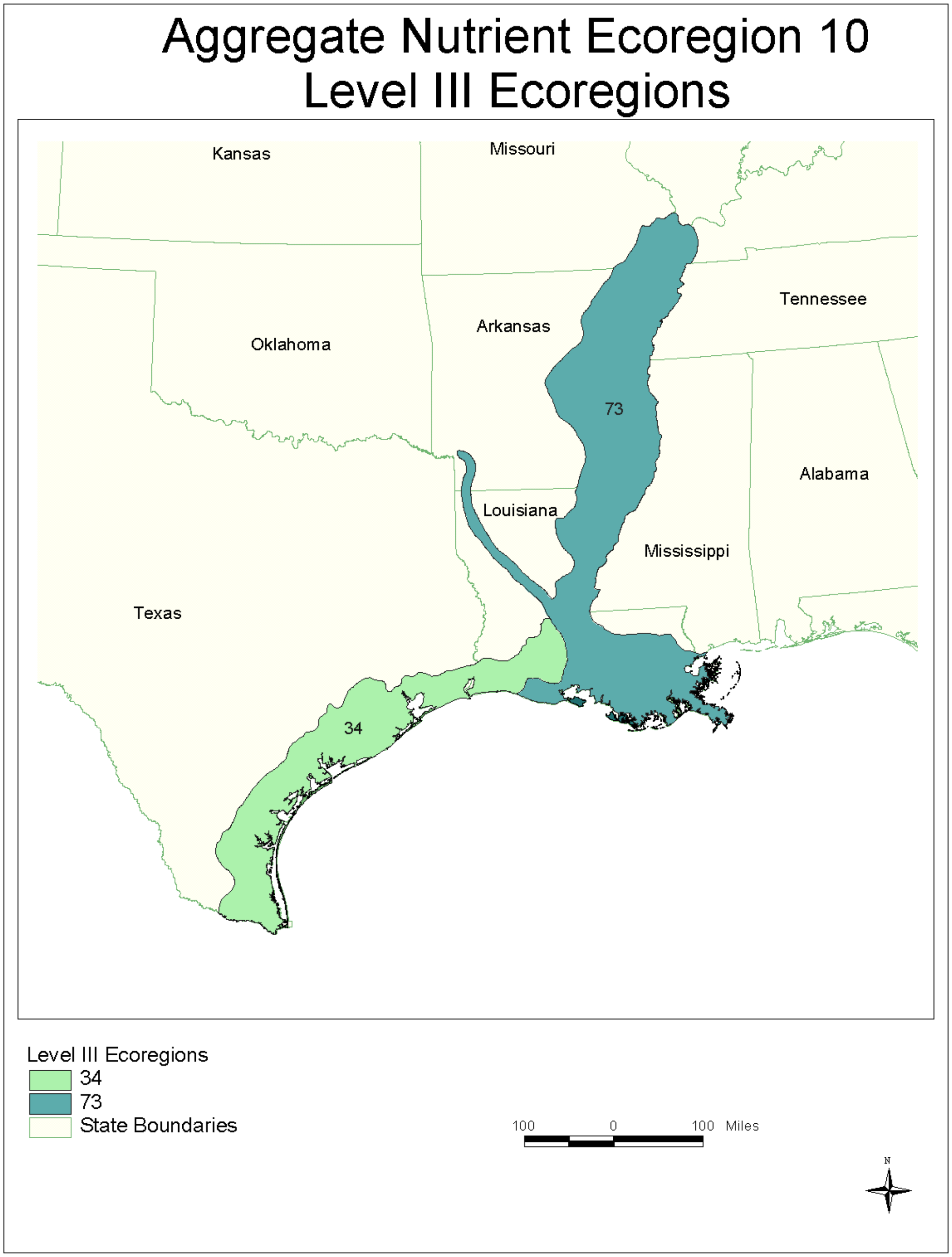


Figure 3. Aggregate Ecoregion X with level III Ecoregions shown.

3.4 Suggested Ecoregional Subdivisions or Adjustments

EPA recommends that the RTAG evaluate the adequacy of EPA nutrient ecoregional and subecoregional boundaries and refine them as needed to reflect local conditions. See the paper by Dale Robertson (USGS, 2001a) for an alternative approach to Ecoregions entitled "An Alternative Regarding the Scheme for Defining Nutrient Criteria for Rivers and Streams."

4.0 DATA REVIEW FOR LAKES AND RESERVOIRS IN AGGREGATE ECOREGION X

This section describes the nutrient data EPA has collected and analyzed for this Ecoregion, including an assessment of data quantity and quality. The data tables present the data for each causal parameter (total phosphorus and total nitrogen, both reported and calculated from TKN and nitrite/nitrate) and the primary response variables (Secchi and chlorophyll *a*). EPA considers these parameters essential to nutrient assessment, because the first two are the main causative agents of enrichment and the two response variables are the early indicators of enrichment for most surface waters (see Chapter 5 of the *Lakes and Reservoirs Nutrient Criteria Technical Guidance Manual* [U.S. EPA, 2000a] for a complete discussion on choosing causal and response variables).

4.1 Data Sources

Data sets from Legacy STORET, NASQAN, EPA Region 7 - Central Plains Center for BioAssessment (CPCB), EPA Region 7 - CPCB2, and EPA Region 7 - REMAP were used to assess nutrient conditions from 1990 to 2000. EPA recommends that the RTAGs identify additional data sources that can be used to supplement the data sets listed above. In addition, the RTAGs may utilize published literature values to support quantitative and qualitative analyses.

4.2 Historical Data from Aggregate Ecoregion X (TP, TN, chl *a*, and Secchi)

EPA recommends that States/Tribes assess long-term trends observed over the past 50 years to assess the relative stability of the systems. This information may be obtained from scientific literature or documentation of historical trends. To gain additional perspective on more recent trends, it is recommended that States and Tribes assess nutrient trends over the past 10 years (e.g., what do seasonal variations indicate?).

4.3 QA/QC of Data Sources

An initial quality screen of data was conducted using the rules presented in Appendix C. Data remaining after screening for duplications and other QA measures (e.g., poor or unreported analytical records, sampling errors or omissions, stations associated with outfalls, stormwater sewers, hazardous waste sites) were used in the statistical analyses.

States within Ecoregion X were contacted regarding the quality of their data and information on the methods used to sample and analyze their waters. The following States indicated standard methods or approved EPA methods were used: Texas, Louisiana, Tennessee, Kentucky, and Illinois. Mississippi indicated that standard or EPA approved methods were used for some specific nutrient parameters. Arkansas and Missouri did not provide information prior to the publication of this document.

4.4 Data for All Lakes and Reservoirs Within Aggregate Ecoregion X

Figure 4 shows the location of the sampling stations within each subecoregion. Table 1 presents all data records for all parameters for Aggregate Ecoregion X and subecoregions within the Aggregate Ecoregion.

4.5 Statistical Analysis of Data

EPA's *Technical Guidance Manual for Developing Nutrient Criteria for Lakes and Reservoirs* describes two ways of establishing a reference condition. One method is to choose the upper 25th percentile (75th percentile) of a reference population of lakes. This is the preferred method. The 75th percentile is preferred by EPA because it is likely associated with minimally impacted conditions, will be protective of designated uses, and provides management flexibility. When reference lakes are not identified, the second method is to determine the lower 25th percentile of the population of all lakes within a region to attempt to approximate the preferred approach. The 25th percentile of the entire population was chosen by EPA to represent a surrogate for an actual reference population. Data analyses to date indicate that the lower 25th percentile from an entire population roughly approximates the 75th percentile for a reference population (see case studies for Minnesota lakes in the *Lakes and Reservoirs Nutrient Criteria Technical Guidance Document* [U.S. EPA, 2000a], the case study for Tennessee streams in the *Rivers and Streams Nutrient Criteria Technical Guidance Document* [U.S. EPA, 2000b], the letter from Tennessee Department of Environment and Conservation to Geoffrey Grubbs [TNDEC, 2000], the unpublished paper titled "Estimating the Natural Background Concentrations of Nutrients in Streams and Rivers of the Conterminous United States" [USGS, 2001]), and the letter from Mathew Liebman, U.S. EPA Region 1 Nutrient Criteria Coordinator to Geoffrey Grubbs [U.S. EPA, 2000c]. New York State has also presented evidence that the 25th percentile and the 75th percentile compare well based on user perceptions of water resources (NYSDEC, 2000).

Tables 2 and 3a-b present potential reference conditions for both the Aggregate Ecoregion and the subecoregions using both methods. However, the reference lake column is left blank because EPA does not have reference data and anticipates that States/Tribes will provide information on reference lakes. Tables 3a-b present potential reference conditions for lakes and reservoirs in the level III subecoregions within the Aggregate Ecoregion. Note that the footnotes for Table 2 apply to Tables 3a-b. Appendixes A and B provide a complete presentation of all descriptive statistics for both the Aggregate Ecoregion and the level III subecoregions.

Table 4 is presented for comparison purposes. It allows the reader to determine where, in the trophic state, the recommended reference conditions fall within traditionally viewed trophic boundaries.

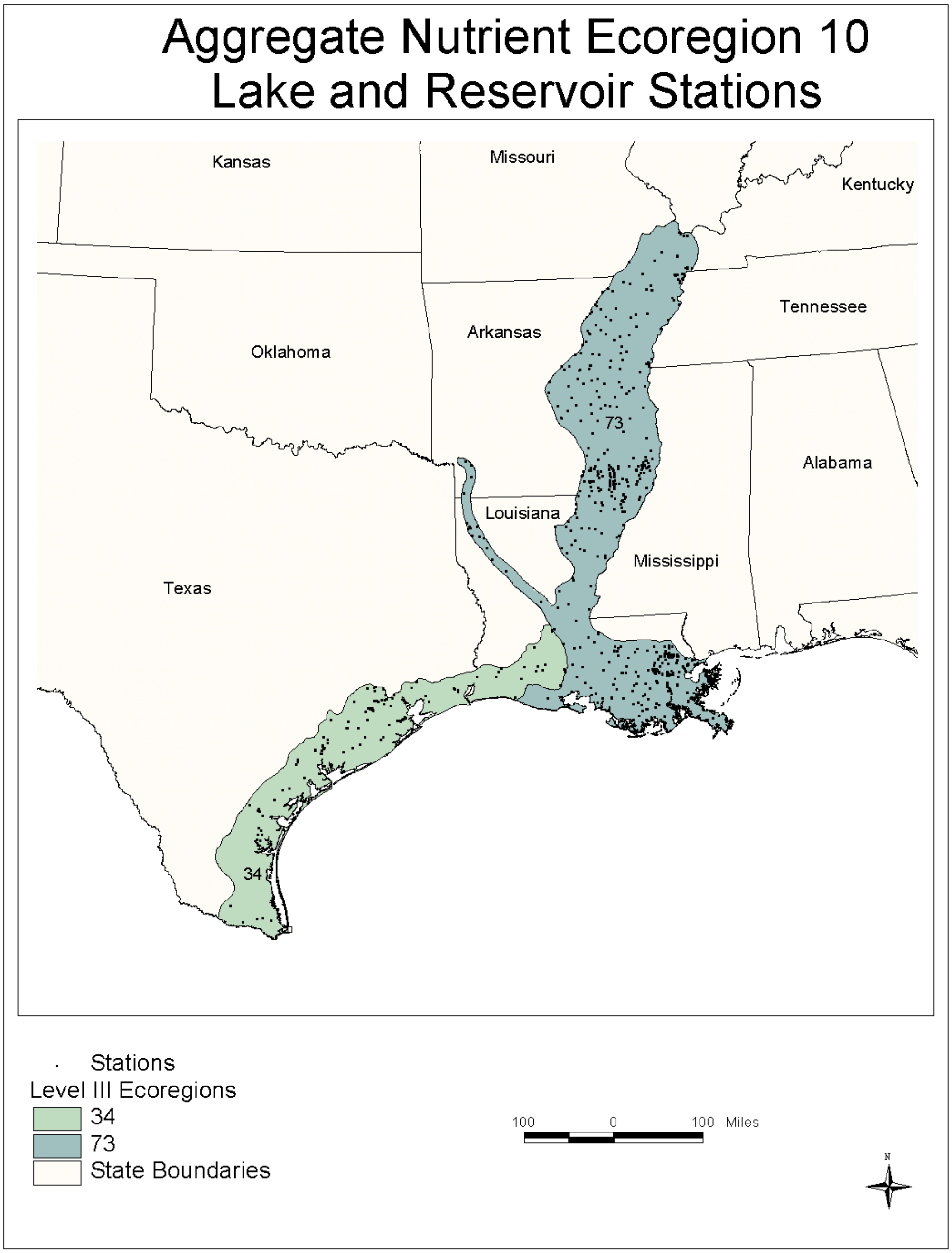


Figure 4. Map of sampling locations within each level III Ecoregion.

Table 1. Lake and Reservoir records* for Aggregate Ecoregion X—Texas-Louisiana Coastal and Mississippi Alluvial Plains

	Aggregate Ecoregion X	Sub ecoR 34	Sub ecoR 73
# of lakes	57	5	52
# of lake stations	200	10	190
Key nutrient parameters (listed below)			
- # of records for Secchi depth	821	106	715
- # of records for chlorophyll *a* (all methods)	91	43	48
- # of records for total Kjeldhal nitrogen (TKN)	1,114	144	970
- # of records for nitrite + nitrate (NO_2+NO_3)	1,307	118	1,189
- # of records for total nitrogen (TN)	—	—	—
- # of records for total phosphorus (TP)	1,426	158	1,268
Total # of records for key nutrient parameters	4,759	569	4,190

Definitions: (1) # of records refers to the total count of observations for that parameter over the entire decade (1990-1999) for that particular aggregate or subecoregion. These are counts for all seasons over that decade. (2) # of lake stations refers to the total number of lake and reservoir stations within the aggregate or subecoregion from which nutrient data were collected. Since lakes and reservoirs can cross ecoregional boundaries, it is important to note that only those portions of a lake or reservoir (and data associated with those stations) that exist within the Ecoregion are included within this table.

*The number of lakes presented in this table is based on the number of lakes and reservoirs for which nutrient data were provided in the National Nutrient database. This does not imply that this is the total of lakes within the Ecoregion. States and Tribes should determine the representativeness of the tabular data by comparing this information with any additional material they may have.

Table 2. Reference conditions for Aggregate Ecoregion X lakes and reservoirs

Parameter	No. of lakes N*	Reported values		25th percentiles based on all seasons data for the decade	Reference lakes§
		Min	Max	P25† all seasons‡	P75 all seasons
TKN (mg/L)	33	0.35	1.90	0.55	
NO_2+NO_3-N (mg/L)	43	0	0.73	0.02	
TN (mg/L) - calculated	NA	—	—	0.57	
TN (mg/L) - reported	—	—	—	—	
TP (µg/L)	44	30	420	60	
Secchi (meters)	24	0.12	1.36	0.8	
Chlorophyll *a* (µg/L) - F	4	16.80	124.40	16.8	
Chlorophyll *a* (µg/L) - S	5	2.15	65.09	5.5	
Chlorophyll *a* (µg/L) - T	1	79.01	79.01	79.0 (zz)	

*N = largest value reported for a decadal season. TN calculated is based on the sum of TKN + NO_2+NO_3. TN reported is actual TN value reported in the database for one sample.
† 75th percentile for Secchi.
‡ Median for all seasons' 25th percentiles, e.g., this value was calculated from four seasons' 25th percentiles. If the seasonal 25th percentile (P25) TP values are: spring 10 µg/L, summer 15 µg/L, fall 12 µg/L, and winter 5 µg/L, the median value of all seasons P25 will be 11µg/L.
§ As determined by the Regional Technical Assistance Groups (RTAGs).

Abbreviations: P25, 25th percentile of all data; P75, 75th percentile of all data; F, Chlorophyll *a* measured by Fluorometric method with acid correction; S, Chlorophyll *a* measured by Spectrophotometric method with acid correction; T, Chlorophyll *a b c* measured by Trichromatic method; —, not applicable.

Definitions: (1) Number of Lakes refers to the largest number of lakes and reservoirs for which data existed for a given season within an aggregate nutrient Ecoregion. (2) Medians. All values (min, max, and 25^{th} percentiles) included in the table are based on waterbody medians. All data for a particular parameter within a lake for the decade were reduced to one median for that lake. This prevents over-representation of individual waterbodies with a great deal of data versus those with fewer data points within the statistical analysis. (3) 25th percentile for all seasons is calculated by taking the median of the 4 seasonal 25^{th} percentiles. If a season is missing, the median was calculated with 3 seasons of data. If fewer than 3 seasons were used to derive the median, the entry is flagged (z). (4) A 25th percentile for a season is best derived with data from a minimum of 4 lakes/season. However, this table provides 25th percentiles that were derived with fewer than 4 lakes/season in order to retain all information for all seasons. In calculating the 25th percentile for a season with fewer than 4 lake medians, the statistical program automatically used the minimum value within the fewer-than-4 population. If fewer than 4 lakes were used in developing a seasonal quartile and or all-seasons median, the entry is flagged (zz).

Note: For seasonal values, refer to Appendix A, "Descriptive Statistics Data Tables for Aggregate Ecoregion."

Table 3a. Reference conditions for Ecoregion X lakes and reservoirs subecoregion 34

Parameter	No. of lakes N*	Reported values		25th percentiles based on all seasons data for the decade	Reference lakes§
		Min	Max	P25† all seasons‡	P75 all seasons
TKN (mg/L)	5	0.70	1.40	0.72 (zz)	
NO_2+NO_3-N (mg/L)	3	0.02	0.52	0.02 (zz)	
TN (mg/L) - calculated	NA			0.74	
TN (mg/L) - reported	—	—	—	—	
TP (µg/L)	4	95	260	115.63 (zz)	
Secchi (meters)	5	0.16	0.86	0.7 (zz)	
Chlorophyll *a* (µg/L) - F	—	—	—	—	
Chlorophyll *a* (µg/L) - S	4	2.15	10.18	3.6	
Chlorophyll *a* (µg/L) - T	—	—	—	—	

Table 3b. Reference conditions for Ecoregion X lakes and reservoirs subecoregion 73

Parameter	No. of lakes N*	Reported values		25th percentiles based on all seasons data for the decade	Reference lakes§
		Min	Max	P25† all seasons‡	P75 all seasons
TKN (mg/L)	28	0.35	1.90	0.53	
NO_2+NO_3-N (mg/L)	40	0	0.36	0.02	
TN (mg/L) - calculated	NA			0.55	
TN (mg/L) - reported	—	—	—	—	
TP (µg/L)	40	30	320	56.25	
Secchi (meters)	19	0.12	1.36	0.8	
Chlorophyll *a* (µg/L) - F	4	16.80	124.40	16.8	
Chlorophyll *a* (µg/L) - S	1	79.21	79.21	79.2 (zz)	
Chlorophyll *a* (µg/L) - T	1	79.01	79.01	79.0 (zz)	

* N = largest value reported for a decadal season. TN calculated is based on the sum of TKN+NO_2+NO_3. TN reported is actual TN value reported in the database for one sample.
† 75th percentile for Secchi.
‡ Median for all seasons' 25th percentiles, e.g., this value was calculated from four seasons' 25th percentiles. If the seasonal 25th percentile (P25) TP values are: spring 10 μg/L, summer 15 μg/L, fall 12 μg/L, and winter 5 μg/L, the median value of all seasons' P25 will be 11μg/L.
§ As determined by the Regional Technical Assistance Groups (RTAGs).

Abbreviations: P25, 25th percentile of all data; P75, 75th percentile of all data; F, Chlorophyll *a* measured by Fluorometric method with acid correction; S, Chlorophyll *a* measured by Spectrophotometric method with acid correction; T, Chlorophyll *a b c* measured by Trichromatic method; —, not applicable; NA, not available.

Definitions: (1) Number of Lakes refers to the number of lakes and reservoirs for which data existed for the summer months since summer is generally when the greatest amount of nutrient sampling is conducted. If another season greatly predominates, notification is made (s=spring, f=fall, w=winter). (2) Medians. All values (min, max, and 25^{th} percentiles) included in the table are based on waterbody medians. All data for a particular parameter within a lake for the decade were reduced to one median for that lake. This prevents over-representation of individual waterbodies with a great deal of data versus those with fewer data points within the statistical analysis. (3) 25th percentile for all seasons is calculated by taking the median of the 4 seasonal 25th percentiles. If a season is missing, the median was calculated with 3 seasons of data. If fewer than 3 seasons were used to derive the median, the entry is flagged (z). (4) A 25th percentile for a season is best derived with data from a minimum of 4 lakes/season. However, this table provides 25th percentiles that were derived with fewer than 4 lakes/season in order to retain all information for all seasons. In calculating the 25th percentile for a season with fewer than 4 lake medians, the statistical program automatically used the minimum value within the fewer-than-4 population. If fewer than 4 lakes were used in developing a seasonal quartile and or all-seasons median, the entry is flagged (zz).

Note: For seasonal and yearly values, refer to Appendix B, "Descriptive Statistics Data Tables for Level III Subecoregions Within Aggregate Ecoregion."

Table 4. Changes in temperate lake attributes according to trophic state (adapted from Carlson and Simpson, 1996)

TSI Value	SD (m)	TP (μg/L)	Attributes	Water Supply	Recreation	Fisheries
<30	>8	<6	Oligotrophy: Clear water, oxygen throughout the year in the hypolimnion			Salmonid fisheries dominate
30-40	8-4	6-12	Hypolimnia of shallower lakes may become anoxic			Salmonid fisheries in deep lakes
40-50	4-2	12-24	Mesotrophy: Water moderately clear but increasing probability of hypolimnetic anoxia during summer	Iron and manganese evident during the summer. THM precursors exceed 0.1 mg/L and turbidity >1 NTU		Hypolimnetic anoxia results in loss of salmonids. Walleye may predominate
50-60	2-1	24-48	Eutrophy: Anoxic hypolimnia, macrophyte problems possible	Iron, manganese, taste, and odor problems worsen		Warm-water fisheries only. Bass may be dominant
60-70	0.5-1	48-96	Blue-green algae dominate, algal scums and macrophyte problems		Weeds, algal scums, and low transparency discourage swimming and boating	
70-80	0.25-0.5	96-192	Hypereutrophy (light limited). Dense algae and macrophytes			
>80	<0.25	192-384	Algal scums, few macrophytes			Rough fish dominate, summer fish kills possible

Note: This table is provided to allow the reader to make comparisons between the ecoregional crriteria provided in this document and traditional nutrient and biological endpoints.

4.6 Classification of Lake/Reservoir Type

Assessing the data by lake type should further reduce the variability in the data analysis. There were no readily available classification data in the national datasets used to develop these criteria. States and Tribes are strongly encouraged to classify their lakes before developing a final criterion.

4.7 Summary of Data Reduction Methods

All descriptive statistics were calculated using the medians for each lake within **Ecoregion X** for which data existed. For example, if one lake had 300 observations for phosphorus over the decade or 1 year's time, one median resulted. Each median from each lake was then used in calculating the percentiles for phosphorus for the aggregate nutrient Ecoregion/subecoregion (level III Ecoregion) by season and year (Figures 5a, 5b).

Preferred Data Choices and Recommendations When Data Are Missing

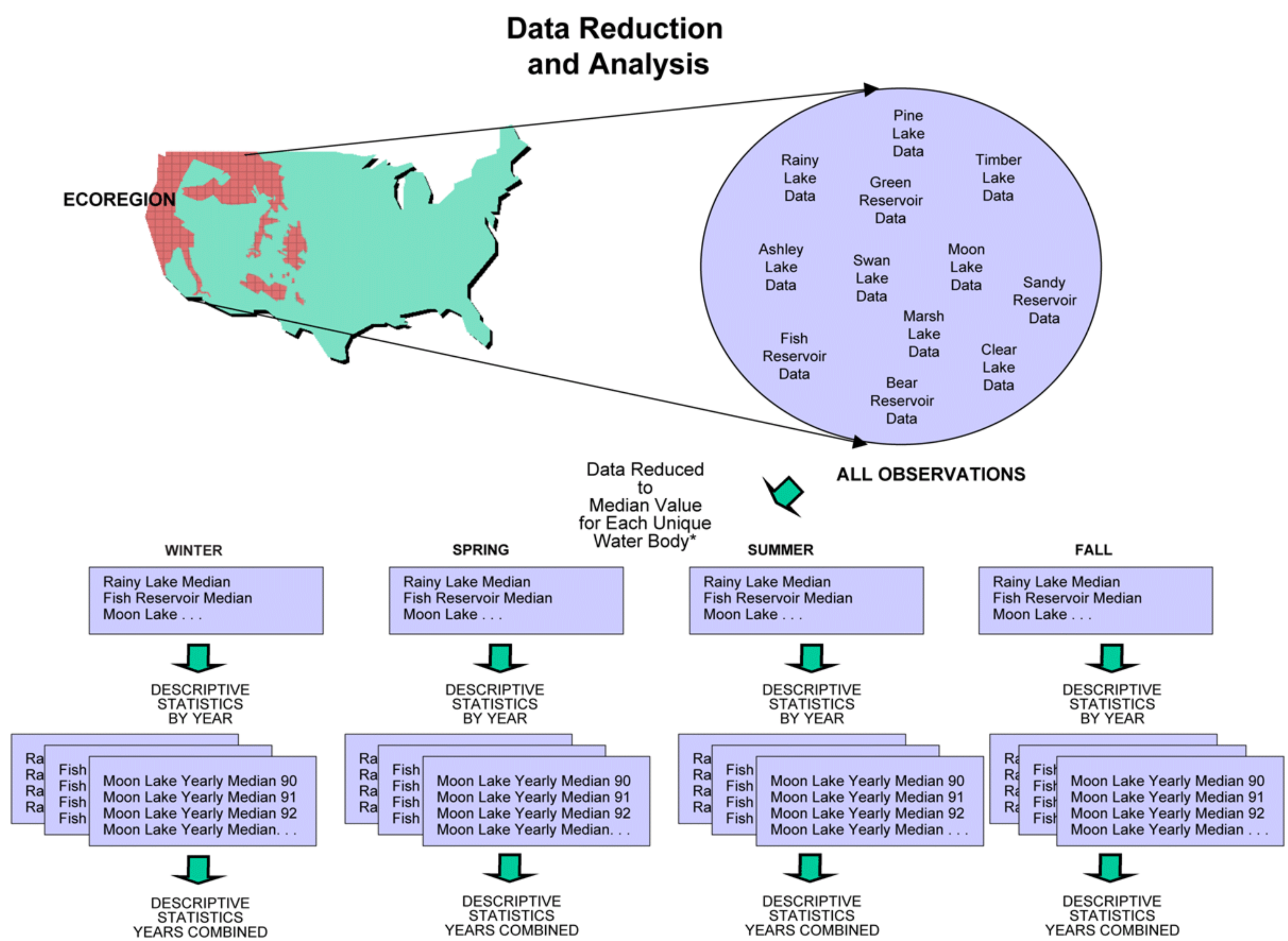
1. **Where data are missing** or are very low in total records for a given parameter, use 25th percentiles for parameters within an adjacent, similar subecoregion within the same aggregate nutrient Ecoregion, **or** when a similar subecoregion cannot be determined, use the the 25th percentile for the Aggregate Ecoregion or consider the **lowest** 25th percentile from a subecoregion (level III) within the aggregate nutrient Ecoregion. Without data, one may assume that the subecoregion in question is as sensitive as the most sensitive subecoregion within the aggregate.

2. **TN calculated:** When reported total nitrogen (TN) median values are lacking or very low in comparison to TKN and Nitrate/Nitrite-N values, the medians for TKN and nitrite/nitrate-N are added, resulting in a calculated TN value. The number of samples (N) for calculated TN is not filled in because it is represented by two subsamples of data: TKN and nitrite/nitrate-N. Therefore, N/A is placed in this box. (Note: TN calculated from TKN and $N0_2$+No_3 should only be done on the same samples).

3. **TN reported:** This is the median based on reported values for TN from the database.

4. **Chlorophyll *a*:** Medians based on all methods are reported; however, the acid-corrected medians are preferred to the uncorrected medians. In developing a reference condition from a particular method, it is recommended that the method with the most observations be used. Fluorometric and spectrophotometric observations are preferred over all other methods. However, when no data exist for fluorometric and spectrophotometric methods, trichromatic values may be used. Data from the various techniques are not interchangeable.

5. **Secchi depth:** The 75th percentile is reported for Secchi depth because this is the only variable for which the value of the parameter **increases** with greater clarity (for lakes and reservoirs only).



Unique Water Body - is a water body that is unique to a state, a subecoregion, a county, the year, and the season.

Figure 5a. Illustration of data reduction process for lake data.

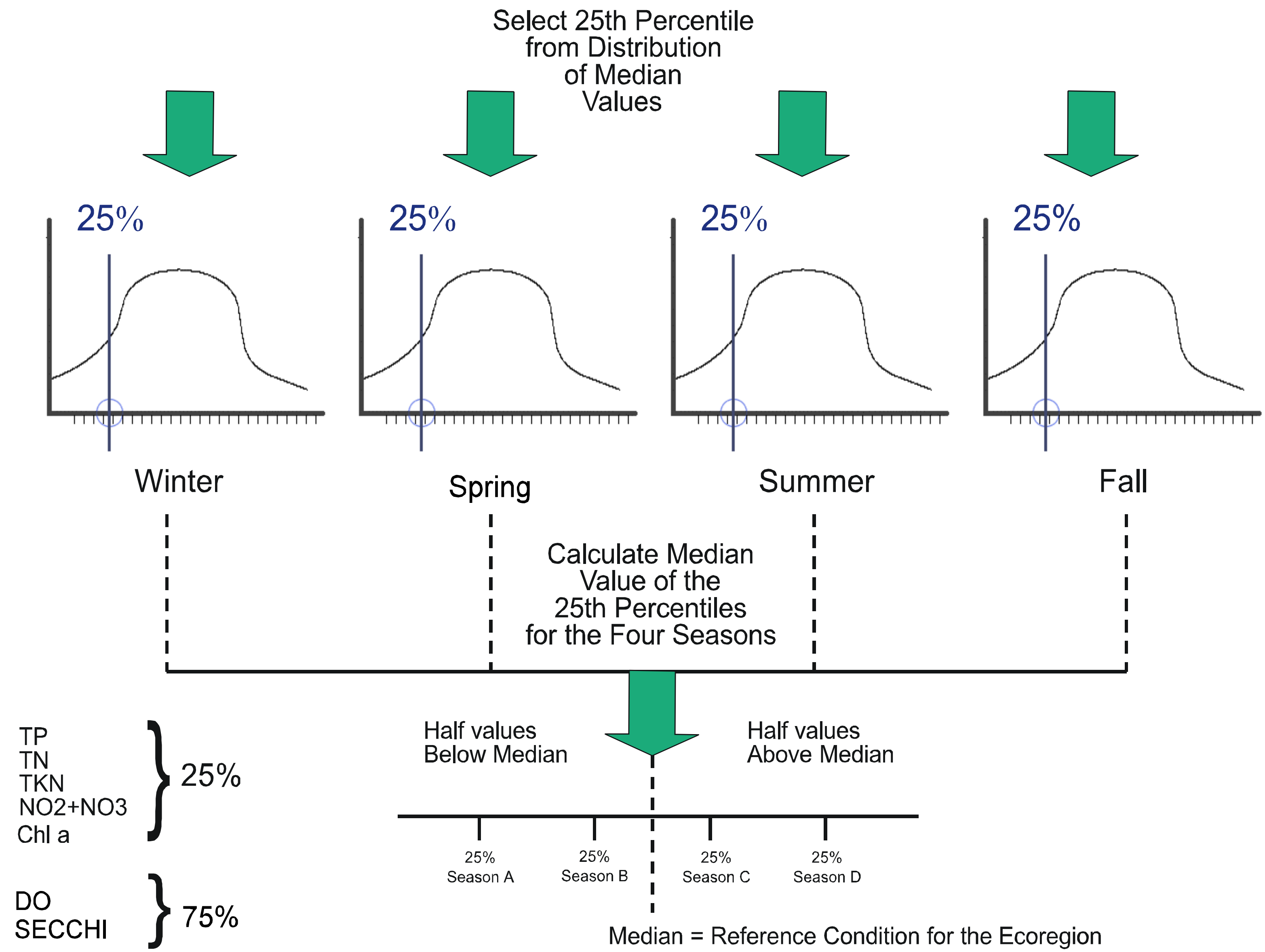


Figure 5b. Illustration of reference condition calculation.

6. **Lack of data:** A dash (—) represents missing, inadequate, or inconclusive data. According to EPA statistical analyses, 5% or fewer of the reported observations are "below detection." Because of this low incidence, these data were retained and factored into the statistical analysis as reported according to the protocols described in Appendix C, "Quality Control/Quality Assurance Rules."

5.0 REFERENCE SITES AND CONDITIONS IN AGGREGATE ECOREGION X

Reference conditions represent the natural, least impacted conditions, or what is considered to be the most attainable conditions. This chapter compares the different reference conditions determined from the two methods and establishes which reference condition is most appropriate.

- *A priori* determination of reference sites. The preferred method for establishing reference condition is to choose the upper percentile of an a priori population of reference lakes. States and Tribes are encouraged to identify reference conditions based on this method.

- Statistical determination of reference conditions (25th percentile of entire database). See Tables 2 and 3a-b in Section 4.0.

- RTAG discussion and rationale for selection of reference sites and conditions in Ecoregion X. The RTAG should compare the results derived from the two methods described above and present a rationale for the final selection of reference sites.

6.0 MODELS USED TO PREDICT OR VERIFY RESPONSE PARAMETERS

The RTAG is encouraged to identify and apply relevant models to support nutrient criteria development. There are three scenarios under which models may be used to derive criteria or support criteria development:

- Models for predicting correlations between causal and response variables

- Models used to verify reference conditions based on percentiles

- Regression models used to predict reference conditions in impacted areas

Appendix C of the Rivers and Streams Technical Guidance Manual (U.S. EPA, 2000b), and Chapter 9 of the Lakes and Reservoirs Technical Guidance Manual (U.S. EPA, 2000a) should be consulted for further details.

7.0 FRAMEWORK FOR REFINING RECOMMENDED NUTRIENT CRITERIA FOR LAKES AND RESERVOIRS IN AGGREGATE ECOREGION X

Information on each of the following six weight-of-evidence factors is important to refine the criteria presented in this document. All elements should be addressed in developing criteria, as is expressed in EPA's nutrient criteria technical guidance manuals. It is our expectation that EPA Regions, States, and Tribes (as RTAGs) will consider these elements as States/Tribes develop their criteria. This section should be viewed as a worksheet (sections are left blank for this purpose) to assist in the refinement of nutrient criteria. If many of these elements are ultimately unaddressed, EPA may rely on the proposed reference conditions presented in Tables 3a-b and other literature and information readily available to the EPA Headquarters nutrient team to develop nutrient water quality recommendations for this Ecoregion.

7.1 Example Worksheet for Developing Aggregate Ecoregion and Subecoregion Nutrient Criteria

Literature sources:

Historical data and trends:

Reference condition:

Models:

RTAG expert review and consensus:

*Downstream effects:*____

7.2 Setting Seasonal Criteria

The recommendations presented in this document are based in part on medians of all the 25th percentile seasonal data (decadal), and as such reflect all seasons and not one particular season or year. It is recommended that States and Tribes monitor in all seasons to best assess compliance with the resulting criterion. States/Tribes may choose to develop criteria that reflect **each** particular season or **given season** or a **given year** when there is significant variability between seasons/years or designated uses that are specifically tied to one or more seasons of the year (e.g., recreation, fishing). Using the tables in Appendix A and B, one can set reference conditions based on a particular season or year and then develop a criterion based on each individual season. Obviously, this option is season-specific and would require increased monitoring within each season to assess compliance. If a case can be made that one season is more appropriate than another season or more appropriate than the annual median, criteria should be season specific. For example, in most parts of the country, spring and summer are the most common growth periods, so criteria for chlorophyll *a* and Secchi may be set for spring and summer only. However, caution should be used when developing criteria for TN and TP because the peak loading of these nutrients may take place in seasons other than summer, such as winter and spring. For these reasons, EPA developed annual criteria and provided additional seasonal information in appendices.

7.3 When Data/Reference Conditions Are Lacking

When data are unavailable to develop a reference condition for a particular parameter(s) within a subecoregion, EPA recommends one of three options: (1) use data from a similar neighboring subecoregion (e.g., if data are few or nonexistent for the Northern Cascades, consider using the data and reference conditions developed for the Cascades); (2) use the 25th percentiles for the Aggregate Ecoregion; or (3) consider using the lowest of the yearly medians for that parameter calculated for all the subecoregions within the Aggregate Ecoregion.

7.4 Site-Specific Criteria Development

Criteria may be refined in a number of ways. The best way is to follow the critical elements of criteria development as well as to refer to the *Lakes and Reservoirs Nutrient Criteria Technical Guidance Manual* (U.S. EPA, 2000a). The Technical Guidance Manual presents sections on each of the following factors to consider in setting criteria:

- Refinements to Ecoregions (Chapter 3). See paper by Dale Robertson (USGS, 2001b), an alternative approach to Ecoregions entitled “An Alternative Regarding the Scheme for Defining Nutrient Criteria for Rivers and Streams.”
- Classification of waterbodies (Chapter 3)

- Setting seasonal criteria to reflect major seasonal climate differences and accounting for significant or cyclical precipitation events (high-flow/low-flow conditions) (Chapter 7)
- Setting criteria for reservoirs only. (The technical guidance manual recommends that data be separated for lakes and reservoirs and treated independently if possible because of differing physical conditions that occur in lakes and reservoirs. In this document all data from both reservoirs and lakes were considered together since STORET does not allow for the differentiation of data except by waterbody name.)

8.0 LITERATURE CITED

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9.0 APPENDICES

A. Descriptive Statistics Data Tables for Aggregate Ecoregion
B. Descriptive Statistics Data Tables for Level III Subecoregions Within Aggregate Ecoregion
C. Quality Control/Quality Assurance Rules

APPENDIX A

Descriptive Statistics Data Tables for Aggregate Ecoregion

Aggregate Nutrient Ecoregion: X 1
Lakes and Reservoirs
Descriptive Statistics by Decade and Season
from 1991 to 1991
Chloro_A_Fluor_cor_ug_L

season	N	MEAN	MIN	MAX	STDDEV	STDERR	CV	P5	P25	MEDIAN	P75	P95
FALL	3	85.97	35.400	126.20	46.27	26.72	54	35.40	35.40	96.30	126.20	126.20
SPRING	4	48.70	7.1000	88.40	42.89	21.45	88	7.10	11.75	49.65	85.65	88.40
SUMMER	3	71.63	16.800	124.40	53.83	31.08	75	16.80	16.80	73.70	124.40	124.40

Data were not always available for all years.

Aggregate Nutrient Ecoregion: X 2
Lakes and Reservoirs
Descriptive Statistics by Decade and Season
from 1990 to 1997
Chloro_A_Phyto_Spec_A_ug_L

season	N	MEAN	MIN	MAX	STDDEV	STDERR	CV	P5	P25	MEDIAN	P75	P95
FALL	5	26.27	4.3000	79.21	30.32	13.56	115	4.30	9.65	16.60	21.60	79.21
SPRING	5	14.75	.25000	50.97	20.51	9.17	139	0.25	5.91	8.23	8.40	50.97
SUMMER	4	32.39	4.0450	107.55	50.22	25.11	155	4.05	5.02	8.98	59.75	107.55
WINTER	2	1.74	.25000	3.23	2.10	1.49	121	0.25	0.25	1.74	3.23	3.23

Data were not always available for all years.

Aggregate Nutrient Ecoregion: X 3
Lakes and Reservoirs
Descriptive Statistics by Decade and Season
from 1991 to 1997
Chloro_A_Trich_unco_ug_L

season	N	MEAN	MIN	MAX	STDDEV	STDERR	CV	P5	P25	MEDIAN	P75	P95
FALL	1	79.01	79.010	79.01	.	.	.	79.01	79.01	79.01	79.01	79.01
SPRING	1	56.59	56.585	56.59	.	.	.	56.59	56.59	56.59	56.59	56.59
SUMMER	1	108.72	108.72	108.72	.	.	.	108.72	108.72	108.72	108.72	108.72

Data were not always available for all years.

Aggregate Nutrient Ecoregion: X 4
Lakes and Reservoirs
Descriptive Statistics by Decade and Season
from 1990 to 1998
Dissolved_Oxygen_mg_L

season	N	MEAN	MIN	MAX	STDDEV	STDERR	CV	P5	P25	MEDIAN	P75	P95
FALL	23	7.61	2.8000	9.80	1.47	0.31	19	6.40	6.75	7.80	8.40	9.70
SPRING	29	7.96	3.4000	10.70	1.67	0.31	21	4.50	7.40	8.50	8.95	10.05
SUMMER	39	6.08	2.2500	11.70	2.19	0.35	36	2.80	4.40	6.50	7.30	11.00
WINTER	21	9.67	4.9000	11.90	1.74	0.38	18	6.55	8.75	10.23	10.70	11.60

Data were not always available for all years.

Aggregate Nutrient Ecoregion: X 5
Lakes and Reservoirs
Descriptive Statistics by Decade and Season
from 1990 to 1998
Nitrite_Nitrate_NO2_NO3_mg_L

season	N	MEAN	MIN	MAX	STDDEV	STDERR	CV	P5	P25	MEDIAN	P75	P95
FALL	20	0.06	.00250	0.29	0.08	0.02	125	0.00	0.01	0.05	0.07	0.26
SPRING	31	0.29	.00500	1.29	0.38	0.07	129	0.01	0.04	0.08	0.61	1.22
SUMMER	43	0.06	.00250	0.37	0.09	0.01	159	0.01	0.01	0.02	0.05	0.29
WINTER	19	0.22	.00500	1.09	0.25	0.06	112	0.01	0.07	0.15	0.25	1.09

Data were not always available for all years.

Aggregate Nutrient Ecoregion: X 6
Lakes and Reservoirs
Descriptive Statistics by Decade and Season
from 1990 to 1998
Nitrogen_Tot_Kjeldhal_mg_L

season	N	MEAN	MIN	MAX	STDDEV	STDERR	CV	P5	P25	MEDIAN	P75	P95
FALL	22	0.91	.30000	1.71	0.42	0.09	47	0.49	0.51	0.81	1.19	1.69
SPRING	33	0.87	.28500	2.30	0.44	0.08	51	0.46	0.56	0.70	1.01	1.85
SUMMER	24	0.95	.39000	2.09	0.46	0.09	49	0.41	0.54	0.90	1.18	2.00
WINTER	17	0.84	.44500	1.46	0.27	0.07	33	0.45	0.67	0.79	0.99	1.46

Data were not always available for all years.

Aggregate Nutrient Ecoregion: X
Lakes and Reservoirs
Descriptive Statistics by Decade and Season
from 1990 to 1998
SECCHI_m

season	N	MEAN	MIN	MAX	STDDEV	STDERR	CV	P5	P25	MEDIAN	P75	P95
FALL	21	0.64	.21590	1.94	0.45	0.10	70	0.23	0.33	0.40	0.81	1.24
SPRING	24	0.51	.10160	1.19	0.32	0.07	62	0.13	0.25	0.48	0.73	1.14
SUMMER	23	0.56	.13970	1.22	0.36	0.07	64	0.15	0.30	0.42	0.81	1.19
WINTER	19	0.56	.10160	1.49	0.36	0.08	64	0.10	0.32	0.51	0.69	1.49

Data were not always available for all years.

Aggregate Nutrient Ecoregion: X
Lakes and Reservoirs
Descriptive Statistics by Decade and Season
from 1990 to 1998
Total_Phosphorus_ug_L

season	N	MEAN	MIN	MAX	STDDEV	STDERR	CV	P5	P25	MEDIAN	P75	P95
FALL	26	122.98	30.000	440.00	89.61	17.57	73	35.00	50.00	111.25	155.00	240.00
SPRING	37	123.48	5.0000	400.00	92.24	15.16	75	5.00	55.00	100.00	160.00	290.00
SUMMER	44	174.12	42.500	1115.00	169.64	25.57	97	47.50	87.50	140.00	205.00	335.00
WINTER	20	105.00	30.000	240.00	49.96	11.17	48	38.75	65.00	108.75	130.00	207.50

Data were not always available for all years.

APPENDIX B

Descriptive Statistics Data Tables for Level III Subecoregions Within Aggregate Ecoregion

Aggregate Nutrient Ecoregion: X
Lakes and Reservoirs
Descriptive Statistics by Subecoregion, Decade and Season
from 1991 to 1991
Chloro_A_Fluor_cor_ug_L

subecoregion	season	N	MEAN	MIN	MAX	STDDEV	STDERR	CV	P5	P25	MEDIAN	P75	P95
73	FALL	3	85.97	35.400	126.20	46.3	26.7	54	35.4	35.4	96.3	126	126
73	SPRING	4	48.70	7.1000	88.40	42.9	21.4	88	7.10	11.8	49.7	85.7	88.4
73	SUMMER	3	71.63	16.800	124.40	53.8	31.1	75	16.8	16.8	73.7	124	124

Data were not always available for all years.

Aggregate Nutrient Ecoregion: X
Lakes and Reservoirs
Descriptive Statistics by Subecoregion, Decade and Season
from 1990 to 1997
Chloro_A_Phyto_Spec_A_ug_L

subecoregion	season	N	MEAN	MIN	MAX	STDDEV	STDERR	CV	P5	P25	MEDIAN	P75	P95
34	FALL	4	13.04	4.3000	21.60	7.61	3.81	58	4.30	6.98	13.1	19.1	21.6
34	SPRING	4	5.70	.25000	8.40	3.80	1.90	67	0.25	3.08	7.07	8.31	8.40
34	SUMMER	3	7.33	4.0450	11.95	4.12	2.38	56	4.05	4.05	6.00	12.0	12.0
34	WINTER	2	1.74	.25000	3.23	2.10	1.49	121	0.25	0.25	1.74	3.23	3.23
73	FALL	1	79.21	79.210	79.21	.	.	.	79.2	79.2	79.2	79.2	79.2
73	SPRING	1	50.97	50.970	50.97	.	.	.	51.0	51.0	51.0	51.0	51.0
73	SUMMER	1	107.55	107.55	107.55	.	.	.	108	108	108	108	108

Data were not always available for all years.

Aggregate Nutrient Ecoregion: X
Lakes and Reservoirs
Descriptive Statistics by Subecoregion, Decade and Season
from 1991 to 1997
Chloro_A_Trich_unco_ug_L

subecoregion	season	N	MEAN	MIN	MAX	STDDEV	STDERR	CV	P5	P25	MEDIAN	P75	P95
73	FALL	1	79.01	79.010	79.01	.	.	.	79.0	79.0	79.0	79.0	79.0
73	SPRING	1	56.59	56.585	56.59	.	.	.	56.6	56.6	56.6	56.6	56.6
73	SUMMER	1	108.72	108.72	108.72	.	.	.	109	109	109	109	109

Data were not always available for all years.

Aggregate Nutrient Ecoregion: X
Lakes and Reservoirs
Descriptive Statistics by Subecoregion, Decade and Season
from 1990 to 1998
Dissolved_Oxygen_mg_L

subecoregion	season	N	MEAN	MIN	MAX	STDDEV	STDERR	CV	P5	P25	MEDIAN	P75	P95
34	FALL	4	6.88	2.8000	9.70	3.04	1.52	44	2.80	4.60	7.50	9.15	9.70
34	SPRING	5	5.70	3.4000	7.50	1.70	0.76	30	3.40	4.50	6.30	6.80	7.50
34	SUMMER	4	5.20	2.9000	7.55	1.94	0.97	37	2.90	3.80	5.18	6.60	7.55
34	WINTER	5	7.93	4.9000	10.80	2.26	1.01	29	4.90	6.55	8.65	8.75	10.8
73	FALL	19	7.76	6.4000	9.80	0.98	0.22	13	6.40	6.80	7.80	8.05	9.80
73	SPRING	24	8.43	5.1000	10.70	1.25	0.25	15	5.65	7.90	8.65	9.05	10.1
73	SUMMER	35	6.18	2.2500	11.70	2.22	0.37	36	2.80	4.40	6.80	7.30	11.0
73	WINTER	16	10.21	7.4000	11.90	1.16	0.29	11	7.40	9.98	10.5	10.8	11.9

Aggregate Nutrient Ecoregion: X
Lakes and Reservoirs
Descriptive Statistics by Subecoregion, Decade and Season
from 1990 to 1998
Nitrite_Nitrate_NO2_NO3_mg_L

subecoregion	season	N	MEAN	MIN	MAX	STDDEV	STDERR	CV	P5	P25	MEDIAN	P75	P95
34	FALL	3	0.03	.01000	0.08	0.04	0.02	116	0.01	0.01	0.01	0.08	0.08
34	SPRING	3	0.43	.00500	0.67	0.37	0.21	86	0.01	0.01	0.61	0.67	0.67
34	SUMMER	3	0.16	.02000	0.37	0.19	0.11	118	0.02	0.02	0.09	0.37	0.37
34	WINTER	3	0.55	.15000	1.09	0.48	0.28	89	0.15	0.15	0.40	1.09	1.09
73	FALL	17	0.06	.00250	0.29	0.08	0.02	123	0.00	0.01	0.05	0.06	0.29
73	SPRING	28	0.28	.00500	1.29	0.38	0.07	137	0.01	0.04	0.08	0.36	1.22
73	SUMMER	40	0.05	.00250	0.31	0.08	0.01	159	0.01	0.01	0.02	0.05	0.28
73	WINTER	16	0.16	.00500	0.42	0.13	0.03	80	0.01	0.05	0.12	0.24	0.42

Data were not always available for all years.

Aggregate Nutrient Ecoregion: X
Lakes and Reservoirs
Descriptive Statistics by Subecoregion, Decade and Season
from 1990 to 1998
Nitrogen_Tot_Kjeldhal_mg_L

subecoregion	season	N	MEAN	MIN	MAX	STDDEV	STDERR	CV	P5	P25	MEDIAN	P75	P95
34	FALL	5	0.87	.53500	1.34	0.33	0.15	38	0.54	0.61	0.84	1.05	1.34
34	SPRING	5	0.91	.70000	1.53	0.35	0.16	39	0.70	0.70	0.75	0.85	1.53
34	SUMMER	4	0.83	.72500	0.93	0.09	0.04	11	0.73	0.76	0.83	0.90	0.93
34	WINTER	4	0.94	.70000	1.46	0.35	0.17	37	0.70	0.74	0.81	1.14	1.46
73	FALL	17	0.92	.30000	1.71	0.46	0.11	50	0.30	0.51	0.77	1.19	1.71
73	SPRING	28	0.86	.28500	2.30	0.46	0.09	54	0.46	0.54	0.68	1.06	1.85
73	SUMMER	20	0.98	.39000	2.09	0.51	0.11	52	0.40	0.53	1.09	1.20	2.05
73	WINTER	13	0.80	.44500	1.21	0.25	0.07	31	0.45	0.64	0.79	0.99	1.21

Data were not always available for all years.

Aggregate Nutrient Ecoregion: X
Lakes and Reservoirs
Descriptive Statistics by Subecoregion, Decade and Season
from 1990 to 1998
SECCHI_m

subecoregion	season	N	MEAN	MIN	MAX	STDDEV	STDERR	CV	P5	P25	MEDIAN	P75	P95
34	FALL	5	0.65	.22500	1.22	0.45	0.20	69	0.23	0.36	0.40	1.05	1.22
34	SPRING	5	0.46	.14000	0.76	0.28	0.13	61	0.14	0.20	0.50	0.70	0.76
34	SUMMER	4	0.46	.16250	0.97	0.36	0.18	79	0.16	0.20	0.35	0.71	0.97
34	WINTER	4	0.32	.16500	0.45	0.13	0.07	42	0.17	0.21	0.33	0.43	0.45
73	FALL	16	0.64	.21590	1.94	0.47	0.12	73	0.22	0.30	0.44	0.80	1.94
73	SPRING	19	0.53	.10160	1.19	0.33	0.08	63	0.10	0.30	0.46	0.86	1.19
73	SUMMER	19	0.58	.13970	1.22	0.36	0.08	63	0.14	0.30	0.42	0.81	1.22
73	WINTER	15	0.62	.10160	1.49	0.37	0.10	60	0.10	0.33	0.55	0.77	1.49

Data were not always available for all years.

Aggregate Nutrient Ecoregion: X 8

Lakes and Reservoirs

Descriptive Statistics by Subecoregion, Decade and Season

from 1990 to 1998

Total_Phosphorus_ug_L

subecoregion	season	N	MEAN	MIN	MAX	STDDEV	STDERR	CV	P5	P25	MEDIAN	P75	P95
34	FALL	5	195.50	50.000	440.00	146	65.1	74	50.0	150	155	183	440
34	SPRING	5	154.00	90.000	280.00	75.0	33.6	49	90.0	110	130	160	280
34	SUMMER	4	138.13	100.00	180.00	34.6	17.3	25	100	111	136	165	180
34	WINTER	4	152.50	120.00	240.00	58.5	29.3	38	120	120	125	185	240
73	FALL	21	105.71	30.000	240.00	64.6	14.1	61	35.0	50.0	110	130	235
73	SPRING	32	118.71	5.0000	400.00	94.8	16.8	80	5.00	50.0	90.0	155	290
73	SUMMER	40	177.72	42.500	1115.00	177	28.1	100	46.3	75.0	140	215	398
73	WINTER	16	93.13	30.000	175.00	41.5	10.4	45	30.0	62.5	82.5	125	175

Data were not always available for all years.

Aggregate Nutrient Ecoregion: X 1

Lakes and Reservoirs

Descriptive Statistics by Subecoregion, Year and Season

from 1991 to 1991

Chloro_A_Fluor_cor_ug_L

subecoregion	year	season	N	MEAN	MIN	MAX	STDDEV	STDERR	CV	P5	P25	MEDIAN	P75	P95
73	1991	FALL	3	85.97	35.400	126.20	46.27	26.72	54	35.40	35.40	96.30	126.20	126.20
73	1991	SPRING	4	48.70	7.1000	88.40	42.89	21.45	88	7.10	11.75	49.65	85.65	88.40
73	1991	SUMMER	3	71.63	16.800	124.40	53.83	31.08	75	16.80	16.80	73.70	124.40	124.40

Aggregate Nutrient Ecoregion: X
Lakes and Reservoirs
Descriptive Statistics by Subecoregion, Year and Season
from 1990 to 1997
Chloro_A_Phyto_Spec_A_ug_L

subecoregion	year	season	N	MEAN	MIN	MAX	STDDEV	STDERR	CV	P5	P25	MEDIAN	P75	P95
34	1990	FALL	2	4.90	4.3000	5.50	0.85	0.60	17	4.30	4.30	4.90	5.50	5.50
34	1990	SPRING	2	8.28	8.1500	8.40	0.18	0.13	2	8.15	8.15	8.28	8.40	8.40
34	1990	SUMMER	1	6.00	6.0000	6.00	.	.	.	6.00	6.00	6.00	6.00	6.00
34	1991	FALL	3	18.78	.25000	35.20	17.57	10.14	94	0.25	0.25	20.90	35.20	35.20
34	1991	SPRING	2	9.51	8.2250	10.80	1.82	1.29	19	8.23	8.23	9.51	10.80	10.80
34	1991	SUMMER	2	11.63	5.9500	17.30	8.03	5.68	69	5.95	5.95	11.63	17.30	17.30
34	1991	WINTER	1	6.20	6.2000	6.20	.	.	.	6.20	6.20	6.20	6.20	6.20
34	1992	FALL	3	11.55	.25000	20.10	10.21	5.89	88	0.25	0.25	14.30	20.10	20.10
34	1992	SPRING	3	11.20	.25000	21.85	10.80	6.24	96	0.25	0.25	11.50	21.85	21.85
34	1992	SUMMER	1	2.30	2.3000	2.30	.	.	.	2.30	2.30	2.30	2.30	2.30
34	1992	WINTER	1	0.25	.25000	0.25	.	.	.	0.25	0.25	0.25	0.25	0.25
34	1993	FALL	2	17.70	13.800	21.60	5.52	3.90	31	13.80	13.80	17.70	21.60	21.60
34	1993	SPRING	1	5.91	5.9100	5.91	.	.	.	5.91	5.91	5.91	5.91	5.91
34	1994	FALL	1	0.25	.25000	0.25	.	.	.	0.25	0.25	0.25	0.25	0.25
34	1994	SPRING	1	0.25	.25000	0.25	.	.	.	0.25	0.25	0.25	0.25	0.25
34	1994	SUMMER	1	2.14	2.1400	2.14	.	.	.	2.14	2.14	2.14	2.14	2.14
34	1995	FALL	2	20.15	16.600	23.70	5.02	3.55	25	16.60	16.60	20.15	23.70	23.70
34	1995	SPRING	1	6.01	6.0100	6.01	.	.	.	6.01	6.01	6.01	6.01	6.01
34	1995	SUMMER	1	10.90	10.900	10.90	.	.	.	10.90	10.90	10.90	10.90	10.90
34	1995	WINTER	1	0.25	.25000	0.25	.	.	.	0.25	0.25	0.25	0.25	0.25
34	1996	SPRING	2	0.25	.25000	0.25	0.00	0.00	0	0.25	0.25	0.25	0.25	0.25
34	1996	SUMMER	1	13.00	13.000	13.00	.	.	.	13.00	13.00	13.00	13.00	13.00
34	1996	WINTER	1	0.25	.25000	0.25	.	.	.	0.25	0.25	0.25	0.25	0.25
73	1991	FALL	1	79.21	79.210	79.21	.	.	.	79.21	79.21	79.21	79.21	79.21
73	1991	SPRING	1	48.06	48.060	48.06	.	.	.	48.06	48.06	48.06	48.06	48.06
73	1991	SUMMER	1	130.17	130.17	130.17	.	.	.	130.17	130.17	130.17	130.17	130.17
73	1994	SPRING	1	50.97	50.970	50.97	.	.	.	50.97	50.97	50.97	50.97	50.97
73	1994	SUMMER	1	78.79	78.790	78.79	.	.	.	78.79	78.79	78.79	78.79	78.79
73	1997	SPRING	1	83.51	83.505	83.51	.	.	.	83.51	83.51	83.51	83.51	83.51
73	1997	SUMMER	1	107.55	107.55	107.55	.	.	.	107.55	107.55	107.55	107.55	107.55

Aggregate Nutrient Ecoregion: X
Lakes and Reservoirs
Descriptive Statistics by Subecoregion, Year and Season
from 1991 to 1997
Chloro_A_Trich_unco_ug_L

subecoregion	year	season	N	MEAN	MIN	MAX	STDDEV	STDERR	CV	P5	P25	MEDIAN	P75	P95
73	1991	FALL	1	79.01	79.010	79.01	.	.	.	79.01	79.01	79.01	79.01	79.01
73	1991	SPRING	1	54.63	54.625	54.63	.	.	.	54.63	54.63	54.63	54.63	54.63
73	1991	SUMMER	1	125.05	125.05	125.05	.	.	.	125.05	125.05	125.05	125.05	125.05
73	1994	SPRING	1	56.59	56.585	56.59	.	.	.	56.59	56.59	56.59	56.59	56.59
73	1994	SUMMER	1	89.06	89.060	89.06	.	.	.	89.06	89.06	89.06	89.06	89.06
73	1997	SPRING	1	90.19	90.185	90.19	.	.	.	90.19	90.19	90.19	90.19	90.19
73	1997	SUMMER	1	108.72	108.72	108.72	.	.	.	108.72	108.72	108.72	108.72	108.72

Aggregate Nutrient Ecoregion: X
Lakes and Reservoirs
Descriptive Statistics by Subecoregion, Year and Season
from 1990 to 1998
Dissolved_Oxygen_mg_L

subecoregion	year	season	N	MEAN	MIN	MAX	STDDEV	STDERR	CV	P5	P25	MEDIAN	P75	P95
34	1990	FALL	2	5.83	3.2000	8.45	3.71	2.63	64	3.20	3.20	5.83	8.45	8.45
34	1990	SPRING	2	6.93	6.8000	7.05	0.18	0.13	3	6.80	6.80	6.93	7.05	7.05
34	1990	SUMMER	2	4.05	3.4000	4.70	0.92	0.65	23	3.40	3.40	4.05	4.70	4.70
34	1990	WINTER	1	7.20	7.2000	7.20	.	.	.	7.20	7.20	7.20	7.20	7.20
34	1991	FALL	3	9.30	8.6000	9.70	0.61	0.35	7	8.60	8.60	9.60	9.70	9.70
34	1991	SPRING	3	4.52	2.3000	5.65	1.92	1.11	43	2.30	2.30	5.60	5.65	5.65
34	1991	SUMMER	3	2.63	.20000	5.50	2.68	1.55	102	0.20	0.20	2.20	5.50	5.50
34	1991	WINTER	2	9.43	8.0500	10.80	1.94	1.38	21	8.05	8.05	9.43	10.80	10.80
34	1992	FALL	2	10.05	9.3000	10.80	1.06	0.75	11	9.30	9.30	10.05	10.80	10.80
34	1992	SPRING	4	6.15	2.8000	8.10	2.35	1.18	38	2.80	4.55	6.85	7.75	8.10
34	1992	SUMMER	3	5.12	1.3500	8.60	3.63	2.10	71	1.35	1.35	5.40	8.60	8.60
34	1992	WINTER	1	8.30	8.3000	8.30	.	.	.	8.30	8.30	8.30	8.30	8.30
34	1993	FALL	2	5.85	3.9000	7.80	2.76	1.95	47	3.90	3.90	5.85	7.80	7.80
34	1993	SPRING	3	4.67	.70000	7.10	3.46	2.00	74	0.70	0.70	6.20	7.10	7.10
34	1993	SUMMER	2	5.55	5.2000	5.90	0.49	0.35	9	5.20	5.20	5.55	5.90	5.90
34	1993	WINTER	2	8.08	6.9500	9.20	1.59	1.13	20	6.95	6.95	8.08	9.20	9.20
34	1994	FALL	2	3.45	1.7000	5.20	2.47	1.75	72	1.70	1.70	3.45	5.20	5.20
34	1994	SPRING	3	5.70	4.0000	7.50	1.75	1.01	31	4.00	4.00	5.60	7.50	7.50
34	1994	SUMMER	2	4.33	2.7000	5.95	2.30	1.63	53	2.70	2.70	4.33	5.95	5.95
34	1994	WINTER	2	6.33	4.0500	8.60	3.22	2.27	51	4.05	4.05	6.33	8.60	8.60
34	1995	FALL	2	6.60	4.5000	8.70	2.97	2.10	45	4.50	4.50	6.60	8.70	8.70
34	1995	SPRING	3	6.42	5.8000	6.95	0.58	0.33	9	5.80	5.80	6.50	6.95	6.95
34	1995	SUMMER	3	5.27	2.9000	7.00	2.12	1.23	40	2.90	2.90	5.90	7.00	7.00
34	1995	WINTER	3	7.15	5.5000	8.65	1.58	0.91	22	5.50	5.50	7.30	8.65	8.65
34	1996	SPRING	4	6.41	3.4000	8.50	2.22	1.11	35	3.40	4.80	6.88	8.03	8.50
34	1996	SUMMER	3	5.88	3.9000	8.10	2.11	1.22	36	3.90	3.90	5.65	8.10	8.10
34	1996	WINTER	4	8.18	4.9000	10.40	2.63	1.31	32	4.90	6.05	8.70	10.30	10.40
34	1997	FALL	1	1.50	1.5000	1.50	.	.	.	1.50	1.50	1.50	1.50	1.50
34	1997	SPRING	1	4.50	4.5000	4.50	.	.	.	4.50	4.50	4.50	4.50	4.50
34	1997	SUMMER	1	4.90	4.9000	4.90	.	.	.	4.90	4.90	4.90	4.90	4.90
34	1997	WINTER	2	7.73	6.5500	8.90	1.66	1.18	22	6.55	6.55	7.73	8.90	8.90
34	1998	WINTER	1	3.20	3.2000	3.20	.	.	.	3.20	3.20	3.20	3.20	3.20

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subecoregion	year	season	N	MEAN	MIN	MAX	STDDEV	STDERR	CV	P5	P25	MEDIAN	P75	P95
73	1990	FALL	10	8.04	6.9000	10.15	0.93	0.29	12	6.90	7.50	7.73	8.35	10.15
73	1990	SPRING	11	8.68	5.1000	10.70	1.80	0.54	21	5.10	8.30	8.70	10.40	10.70
73	1990	SUMMER	10	6.81	4.7000	8.85	1.23	0.39	18	4.70	5.95	6.85	7.25	8.85
73	1990	WINTER	10	10.69	9.1500	12.20	0.90	0.28	8	9.15	10.00	10.88	11.15	12.20
73	1991	FALL	4	9.23	8.3000	9.80	0.65	0.33	7	8.30	8.80	9.40	9.65	9.80
73	1991	SPRING	14	7.93	5.6500	10.10	1.21	0.32	15	5.65	7.10	7.95	8.40	10.10
73	1991	SUMMER	14	7.30	4.1000	11.70	1.89	0.51	26	4.10	6.60	7.00	7.60	11.70
73	1991	WINTER	3	10.52	9.6000	11.50	0.95	0.55	9	9.60	9.60	10.45	11.50	11.50
73	1992	FALL	6	8.42	5.3000	12.55	2.52	1.03	30	5.30	6.95	7.90	9.90	12.55
73	1992	SPRING	14	9.18	7.1000	11.05	0.98	0.26	11	7.10	8.75	9.15	9.50	11.05
73	1992	SUMMER	14	7.73	5.0000	11.45	1.83	0.49	24	5.00	6.70	7.20	8.75	11.45
73	1992	WINTER	14	10.30	8.0000	12.40	1.16	0.31	11	8.00	9.80	10.35	10.70	12.40
73	1993	FALL	14	6.72	4.4000	8.40	1.05	0.28	16	4.40	6.20	6.70	7.70	8.40
73	1993	SPRING	11	8.97	7.9000	9.70	0.49	0.15	5	7.90	8.70	8.95	9.30	9.70
73	1993	SUMMER	14	7.49	.20000	12.50	2.72	0.73	36	0.20	7.00	7.30	8.70	12.50
73	1993	WINTER	14	9.56	7.1000	12.75	1.64	0.44	17	7.10	8.40	9.65	10.30	12.75
73	1994	FALL	11	7.58	6.4000	8.55	0.60	0.18	8	6.40	7.30	7.60	7.80	8.55
73	1994	SPRING	13	8.69	7.6000	10.80	0.87	0.24	10	7.60	8.05	8.70	9.10	10.80
73	1994	SUMMER	30	5.78	2.2500	11.00	2.02	0.37	35	2.80	4.00	5.70	7.20	8.45
73	1994	WINTER	11	10.17	7.4000	12.70	1.36	0.41	13	7.40	9.25	10.30	11.00	12.70
73	1995	FALL	11	8.71	6.8000	10.60	1.06	0.32	12	6.80	8.00	8.70	9.40	10.60
73	1995	SPRING	11	8.66	6.3000	10.20	1.01	0.31	12	6.30	8.30	8.90	9.10	10.20
73	1995	SUMMER	11	6.34	2.0000	8.40	1.60	0.48	25	2.00	6.20	6.65	7.10	8.40
73	1995	WINTER	11	10.48	8.5000	11.60	0.87	0.26	8	8.50	10.00	10.60	11.10	11.60
73	1996	FALL	11	7.32	5.6500	8.50	0.82	0.25	11	5.65	6.75	7.40	8.00	8.50
73	1996	SPRING	16	8.89	7.2000	11.50	1.21	0.30	14	7.20	7.80	8.85	9.75	11.50
73	1996	SUMMER	12	6.68	4.6000	8.10	1.14	0.33	17	4.60	5.98	7.00	7.38	8.10
73	1996	WINTER	11	10.44	7.3000	12.20	1.77	0.53	17	7.30	9.50	10.95	11.90	12.20
73	1997	FALL	11	7.61	6.0000	8.40	0.79	0.24	10	6.00	7.50	7.95	8.20	8.40
73	1997	SPRING	11	8.62	6.5000	10.80	1.30	0.39	15	6.50	7.65	8.30	9.60	10.80
73	1997	SUMMER	11	7.45	6.3000	11.10	1.40	0.42	19	6.30	6.70	6.90	7.90	11.10
73	1997	WINTER	12	9.53	6.1000	10.90	1.72	0.50	18	6.10	8.78	10.38	10.50	10.90

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subecoregion	year	season	N	MEAN	MIN	MAX	STDDEV	STDERR	CV	P5	P25	MEDIAN	P75	P95
73	1998	SPRING	7	8.89	6.4000	10.40	1.50	0.57	17	6.40	7.50	9.30	10.20	10.40
73	1998	WINTER	11	9.40	6.0000	11.10	1.52	0.46	16	6.00	8.70	9.90	10.40	11.10

Aggregate Nutrient Ecoregion: X
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from 1990 to 1998
Nitrite_Nitrate_NO2_NO3_mg_L

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subecoregion	year	season	N	MEAN	MIN	MAX	STDDEV	STDERR	CV	P5	P25	MEDIAN	P75	P95
34	1990	SPRING	1	0.70	.70000	0.70	.	.	.	0.70	0.70	0.70	0.70	0.70
34	1990	SUMMER	1	0.03	.02500	0.03	.	.	.	0.03	0.03	0.03	0.03	0.03
34	1990	WINTER	1	0.30	.30000	0.30	.	.	.	0.30	0.30	0.30	0.30	0.30
34	1991	SPRING	2	0.35	.04000	0.67	0.44	0.31	125	0.04	0.04	0.35	0.67	0.67
34	1991	SUMMER	2	0.08	.02000	0.14	0.08	0.06	106	0.02	0.02	0.08	0.14	0.14
34	1991	WINTER	1	0.50	.50000	0.50	.	.	.	0.50	0.50	0.50	0.50	0.50
34	1992	SPRING	2	0.13	.00500	0.26	0.18	0.13	136	0.01	0.01	0.13	0.26	0.26
34	1992	SUMMER	2	0.05	.00500	0.09	0.06	0.04	126	0.01	0.01	0.05	0.09	0.09
34	1992	WINTER	1	0.15	.15000	0.15	.	.	.	0.15	0.15	0.15	0.15	0.15
34	1993	FALL	1	0.02	.02000	0.02	.	.	.	0.02	0.02	0.02	0.02	0.02
34	1993	SPRING	1	0.02	.02000	0.02	.	.	.	0.02	0.02	0.02	0.02	0.02
34	1993	SUMMER	1	0.04	.03750	0.04	.	.	.	0.04	0.04	0.04	0.04	0.04
34	1993	WINTER	1	0.08	.08250	0.08	.	.	.	0.08	0.08	0.08	0.08	0.08
34	1994	FALL	2	0.07	.00500	0.13	0.09	0.06	131	0.01	0.01	0.07	0.13	0.13
34	1994	SPRING	1	0.01	.00500	0.01	.	.	.	0.01	0.01	0.01	0.01	0.01
34	1994	SUMMER	1	0.04	.04250	0.04	.	.	.	0.04	0.04	0.04	0.04	0.04
34	1994	WINTER	1	0.03	.02750	0.03	.	.	.	0.03	0.03	0.03	0.03	0.03
34	1995	FALL	3	0.02	.00500	0.03	0.01	0.01	88	0.01	0.01	0.01	0.03	0.03
34	1995	SPRING	2	0.31	.00500	0.61	0.43	0.30	139	0.01	0.01	0.31	0.61	0.61
34	1995	SUMMER	2	0.19	.00375	0.37	0.26	0.18	139	0.00	0.00	0.19	0.37	0.37
34	1995	WINTER	2	0.59	.14000	1.04	0.64	0.45	108	0.14	0.14	0.59	1.04	1.04
34	1996	SPRING	1	0.01	.00500	0.01	.	.	.	0.01	0.01	0.01	0.01	0.01
34	1996	SUMMER	1	0.02	.02000	0.02	.	.	.	0.02	0.02	0.02	0.02	0.02
34	1996	WINTER	2	0.77	.40000	1.13	0.52	0.37	67	0.40	0.40	0.77	1.13	1.13
34	1997	FALL	1	0.47	.47000	0.47	.	.	.	0.47	0.47	0.47	0.47	0.47
34	1997	SPRING	1	0.08	.08000	0.08	.	.	.	0.08	0.08	0.08	0.08	0.08
34	1997	SUMMER	1	0.03	.02500	0.03	.	.	.	0.03	0.03	0.03	0.03	0.03
34	1997	WINTER	1	0.22	.21500	0.22	.	.	.	0.22	0.22	0.22	0.22	0.22
34	1998	WINTER	1	0.16	.16000	0.16	.	.	.	0.16	0.16	0.16	0.16	0.16
73	1990	FALL	10	0.03	.00500	0.06	0.02	0.01	72	0.01	0.01	0.03	0.06	0.06
73	1990	SPRING	10	0.14	.02000	0.67	0.20	0.06	141	0.02	0.04	0.05	0.20	0.67
73	1990	SUMMER	10	0.02	.00500	0.09	0.03	0.01	117	0.01	0.01	0.01	0.03	0.09

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Nitrite_Nitrate_NO2_NO3_mg_L

subecoregion	year	season	N	MEAN	MIN	MAX	STDDEV	STDERR	CV	P5	P25	MEDIAN	P75	P95
73	1990	WINTER	10	0.13	.04000	0.30	0.08	0.03	66	0.04	0.06	0.12	0.15	0.30
73	1991	FALL	5	0.04	.00250	0.06	0.02	0.01	57	0.00	0.04	0.04	0.05	0.06
73	1991	SPRING	15	0.12	.00500	0.77	0.19	0.05	158	0.01	0.03	0.04	0.11	0.77
73	1991	SUMMER	15	0.05	.00250	0.28	0.07	0.02	148	0.00	0.01	0.03	0.05	0.28
73	1991	WINTER	3	0.14	.08000	0.20	0.06	0.03	41	0.08	0.08	0.15	0.20	0.20
73	1992	FALL	6	0.12	.00500	0.49	0.18	0.07	156	0.01	0.04	0.06	0.06	0.49
73	1992	SPRING	14	0.08	.00500	0.31	0.09	0.02	104	0.01	0.03	0.07	0.08	0.31
73	1992	SUMMER	14	0.10	.00500	0.56	0.17	0.05	176	0.01	0.01	0.01	0.10	0.56
73	1992	WINTER	14	0.12	.00500	0.39	0.13	0.03	105	0.01	0.03	0.06	0.19	0.39
73	1993	FALL	14	0.11	.00500	0.68	0.17	0.05	153	0.01	0.03	0.05	0.12	0.68
73	1993	SPRING	11	0.13	.00500	0.38	0.12	0.04	90	0.01	0.04	0.11	0.19	0.38
73	1993	SUMMER	14	0.10	.00500	0.68	0.19	0.05	186	0.01	0.01	0.04	0.05	0.68
73	1993	WINTER	14	0.14	.00500	0.36	0.11	0.03	83	0.01	0.07	0.10	0.16	0.36
73	1994	FALL	14	0.12	.00250	0.94	0.25	0.07	212	0.00	0.01	0.02	0.11	0.94
73	1994	SPRING	17	0.23	.00500	0.91	0.30	0.07	129	0.01	0.04	0.07	0.39	0.91
73	1994	SUMMER	34	0.06	.00500	0.79	0.15	0.03	225	0.01	0.01	0.02	0.05	0.31
73	1994	WINTER	14	0.15	.00500	0.47	0.16	0.04	105	0.01	0.02	0.11	0.23	0.47
73	1995	FALL	11	0.08	.00500	0.30	0.09	0.03	112	0.01	0.01	0.06	0.10	0.30
73	1995	SPRING	14	0.08	.00500	0.43	0.12	0.03	144	0.01	0.01	0.03	0.11	0.43
73	1995	SUMMER	11	0.16	.00375	1.55	0.46	0.14	279	0.00	0.01	0.02	0.06	1.55
73	1995	WINTER	14	0.19	.00500	0.55	0.17	0.05	91	0.01	0.03	0.20	0.33	0.55
73	1996	FALL	11	0.09	.00500	0.30	0.12	0.04	132	0.01	0.01	0.02	0.27	0.30
73	1996	SPRING	16	0.07	.00500	0.43	0.12	0.03	172	0.01	0.01	0.01	0.06	0.43
73	1996	SUMMER	12	0.06	.00500	0.26	0.09	0.03	138	0.01	0.02	0.02	0.08	0.26
73	1996	WINTER	11	0.34	.03000	1.11	0.36	0.11	105	0.03	0.08	0.20	0.72	1.11
73	1997	FALL	12	0.12	.00250	0.83	0.23	0.07	193	0.00	0.01	0.04	0.09	0.83
73	1997	SPRING	18	0.39	.00250	1.29	0.44	0.10	112	0.00	0.02	0.19	0.73	1.29
73	1997	SUMMER	16	0.12	.00250	0.51	0.15	0.04	129	0.00	0.02	0.07	0.13	0.51
73	1997	WINTER	12	0.23	.00500	1.09	0.31	0.09	135	0.01	0.05	0.12	0.28	1.09
73	1998	SPRING	7	0.14	.03000	0.22	0.07	0.03	48	0.03	0.11	0.13	0.22	0.22
73	1998	WINTER	11	0.43	.05000	3.01	0.86	0.26	200	0.05	0.10	0.12	0.29	3.01

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Nitrogen_Tot_Kjeldhal_mg_L

subecoregion	year	season	N	MEAN	MIN	MAX	STDDEV	STDERR	CV	P5	P25	MEDIAN	P75	P95
34	1990	FALL	2	0.60	.50000	0.70	0.14	0.10	24	0.50	0.50	0.60	0.70	0.70
34	1990	SPRING	2	0.65	.60000	0.70	0.07	0.05	11	0.60	0.60	0.65	0.70	0.70
34	1990	SUMMER	2	0.78	.70000	0.85	0.11	0.08	14	0.70	0.70	0.78	0.85	0.85
34	1990	WINTER	1	0.60	.60000	0.60	.	.	.	0.60	0.60	0.60	0.60	0.60
34	1991	FALL	1	0.57	.57000	0.57	.	.	.	0.57	0.57	0.57	0.57	0.57
34	1991	SPRING	3	0.83	.70000	0.95	0.13	0.07	15	0.70	0.70	0.85	0.95	0.95
34	1991	SUMMER	3	0.88	.70000	1.00	0.16	0.09	18	0.70	0.70	0.95	1.00	1.00
34	1991	WINTER	2	0.88	.70000	1.05	0.25	0.18	28	0.70	0.70	0.88	1.05	1.05
34	1992	SPRING	2	0.63	.56000	0.70	0.10	0.07	16	0.56	0.56	0.63	0.70	0.70
34	1992	SUMMER	2	0.81	.75000	0.87	0.08	0.06	10	0.75	0.75	0.81	0.87	0.87
34	1992	WINTER	1	0.68	.68000	0.68	.	.	.	0.68	0.68	0.68	0.68	0.68
34	1993	FALL	3	0.97	.46000	1.92	0.83	0.48	85	0.46	0.46	0.52	1.92	1.92
34	1993	SPRING	2	1.31	.80000	1.82	0.72	0.51	55	0.80	0.80	1.31	1.82	1.82
34	1993	SUMMER	1	0.82	.81500	0.82	.	.	.	0.82	0.82	0.82	0.82	0.82
34	1993	WINTER	1	0.53	.52500	0.53	.	.	.	0.53	0.53	0.53	0.53	0.53
34	1994	FALL	2	1.13	.97000	1.28	0.22	0.16	19	0.97	0.97	1.13	1.28	1.28
34	1994	SPRING	2	1.16	.59000	1.73	0.81	0.57	69	0.59	0.59	1.16	1.73	1.73
34	1994	SUMMER	2	0.87	.81000	0.92	0.08	0.05	9	0.81	0.81	0.87	0.92	0.92
34	1994	WINTER	1	0.79	.78500	0.79	.	.	.	0.79	0.79	0.79	0.79	0.79
34	1995	FALL	3	1.10	.84000	1.34	0.25	0.14	23	0.84	0.84	1.12	1.34	1.34
34	1995	SPRING	2	1.18	1.0400	1.32	0.20	0.14	17	1.04	1.04	1.18	1.32	1.32
34	1995	SUMMER	2	0.86	.79500	0.93	0.10	0.07	11	0.80	0.80	0.86	0.93	0.93
34	1995	WINTER	2	1.21	.90500	1.51	0.43	0.30	35	0.91	0.91	1.21	1.51	1.51
34	1996	SPRING	3	1.06	.75000	1.52	0.41	0.24	39	0.75	0.75	0.90	1.52	1.52
34	1996	SUMMER	2	1.14	.66000	1.62	0.68	0.48	60	0.66	0.66	1.14	1.62	1.62
34	1996	WINTER	2	1.06	.71000	1.41	0.49	0.35	47	0.71	0.71	1.06	1.41	1.41
34	1997	FALL	1	2.91	2.9100	2.91	.	.	.	2.91	2.91	2.91	2.91	2.91
34	1997	SPRING	1	1.01	1.0100	1.01	.	.	.	1.01	1.01	1.01	1.01	1.01
34	1997	SUMMER	1	0.82	.82000	0.82	.	.	.	0.82	0.82	0.82	0.82	0.82
34	1997	WINTER	1	1.93	1.9300	1.93	.	.	.	1.93	1.93	1.93	1.93	1.93
34	1998	WINTER	1	0.93	.93000	0.93	.	.	.	0.93	0.93	0.93	0.93	0.93
73	1990	FALL	7	0.97	.50000	1.63	0.50	0.19	52	0.50	0.50	0.74	1.57	1.63

Aggregate Nutrient Ecoregion: X
Lakes and Reservoirs
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Nitrogen_Tot_Kjeldhal_mg_L

subecoregion	year	season	N	MEAN	MIN	MAX	STDDEV	STDERR	CV	P5	P25	MEDIAN	P75	P95
73	1990	SPRING	11	1.01	.53000	2.30	0.50	0.15	50	0.53	0.68	0.83	1.13	2.30
73	1990	SUMMER	7	0.86	.51000	1.40	0.38	0.14	44	0.51	0.54	0.69	1.21	1.40
73	1990	WINTER	7	0.80	.50000	1.26	0.30	0.11	37	0.50	0.54	0.68	1.05	1.26
73	1991	FALL	1	1.05	1.0500	1.05	.	.	.	1.05	1.05	1.05	1.05	1.05
73	1991	SPRING	11	0.91	.47000	1.75	0.39	0.12	43	0.47	0.56	0.78	1.08	1.75
73	1991	SUMMER	11	1.17	.59000	2.65	0.63	0.19	54	0.59	0.65	0.99	1.49	2.65
73	1992	FALL	3	1.51	1.0900	1.81	0.37	0.22	25	1.09	1.09	1.62	1.81	1.81
73	1992	SPRING	11	0.81	.43000	1.55	0.36	0.11	45	0.43	0.55	0.65	1.09	1.55
73	1992	SUMMER	11	1.08	.40000	2.42	0.59	0.18	55	0.40	0.56	1.08	1.35	2.42
73	1992	WINTER	11	0.86	.32000	2.36	0.59	0.18	69	0.32	0.42	0.74	0.96	2.36
73	1993	FALL	15	0.69	.30000	1.19	0.34	0.09	49	0.30	0.30	0.63	1.07	1.19
73	1993	SPRING	11	0.63	.36000	1.04	0.22	0.07	35	0.36	0.43	0.70	0.75	1.04
73	1993	SUMMER	11	0.90	.28000	1.97	0.50	0.15	55	0.28	0.36	0.94	1.12	1.97
73	1993	WINTER	11	0.63	.32000	1.18	0.26	0.08	41	0.32	0.44	0.58	0.72	1.18
73	1994	FALL	12	0.77	.29000	1.56	0.44	0.13	57	0.29	0.42	0.65	1.06	1.56
73	1994	SPRING	14	0.89	.02500	3.00	0.71	0.19	81	0.03	0.48	0.70	0.88	3.00
73	1994	SUMMER	15	0.91	.37000	2.00	0.54	0.14	59	0.37	0.43	0.95	1.16	2.00
73	1994	WINTER	11	0.82	.51000	1.51	0.31	0.09	37	0.51	0.53	0.86	0.99	1.51
73	1995	FALL	11	1.35	.61000	2.68	0.65	0.19	48	0.61	0.70	1.37	1.85	2.68
73	1995	SPRING	11	0.98	.43000	1.85	0.43	0.13	44	0.43	0.61	0.84	1.34	1.85
73	1995	SUMMER	11	1.02	.41000	1.71	0.41	0.12	40	0.41	0.64	1.05	1.36	1.71
73	1995	WINTER	11	0.83	.37000	1.98	0.46	0.14	55	0.37	0.44	0.76	0.97	1.98
73	1996	FALL	11	1.07	.45500	1.90	0.37	0.11	35	0.46	0.81	1.09	1.17	1.90
73	1996	SPRING	16	0.83	.32000	2.13	0.47	0.12	57	0.32	0.46	0.72	1.11	2.13
73	1996	SUMMER	12	1.03	.44000	2.36	0.55	0.16	54	0.44	0.57	1.11	1.26	2.36
73	1996	WINTER	11	0.67	.18000	1.42	0.34	0.10	51	0.18	0.40	0.61	0.88	1.42
73	1997	FALL	12	1.22	.49000	2.60	0.64	0.19	53	0.49	0.74	1.19	1.40	2.60
73	1997	SPRING	18	1.08	.28500	3.63	0.94	0.22	87	0.29	0.61	0.67	1.01	3.63
73	1997	SUMMER	16	1.10	.39000	2.09	0.54	0.14	49	0.39	0.59	1.08	1.58	2.09
73	1997	WINTER	12	0.90	.48000	1.38	0.26	0.07	28	0.48	0.77	0.85	1.09	1.38
73	1998	SPRING	7	0.91	.64000	1.63	0.37	0.14	41	0.64	0.65	0.68	1.06	1.63
73	1998	WINTER	11	0.85	.35000	1.44	0.35	0.11	42	0.35	0.45	0.90	1.16	1.44

Aggregate Nutrient Ecoregion: X
Lakes and Reservoirs
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SECCHI_m

subecoregion	year	season	N	MEAN	MIN	MAX	STDDEV	STDERR	CV	P5	P25	MEDIAN	P75	P95
34	1990	FALL	2	0.49	.28750	0.70	0.29	0.21	59	0.29	0.29	0.49	0.70	0.70
34	1990	SPRING	2	0.45	.40000	0.50	0.07	0.05	16	0.40	0.40	0.45	0.50	0.50
34	1990	SUMMER	2	0.43	.40000	0.46	0.04	0.03	10	0.40	0.40	0.43	0.46	0.46
34	1990	WINTER	1	0.30	.30000	0.30	.	.	.	0.30	0.30	0.30	0.30	0.30
34	1991	FALL	2	0.28	.20000	0.36	0.11	0.08	40	0.20	0.20	0.28	0.36	0.36
34	1991	SPRING	2	0.40	.20000	0.60	0.28	0.20	71	0.20	0.20	0.40	0.60	0.60
34	1991	SUMMER	3	0.56	.20000	0.97	0.39	0.22	69	0.20	0.20	0.50	0.97	0.97
34	1991	WINTER	2	0.36	.10000	0.61	0.36	0.26	102	0.10	0.10	0.36	0.61	0.61
34	1992	FALL	3	0.57	.30000	0.90	0.31	0.18	54	0.30	0.30	0.50	0.90	0.90
34	1992	SPRING	3	0.22	.10000	0.37	0.14	0.08	61	0.10	0.10	0.20	0.37	0.37
34	1992	SUMMER	2	0.24	.07500	0.40	0.23	0.16	97	0.08	0.08	0.24	0.40	0.40
34	1992	WINTER	1	0.20	.20000	0.20	.	.	.	0.20	0.20	0.20	0.20	0.20
34	1993	FALL	3	0.51	.02500	1.22	0.63	0.36	121	0.03	0.03	0.30	1.22	1.22
34	1993	SPRING	3	0.32	.14000	0.61	0.26	0.15	81	0.14	0.14	0.20	0.61	0.61
34	1993	SUMMER	1	0.30	.30000	0.30	.	.	.	0.30	0.30	0.30	0.30	0.30
34	1993	WINTER	1	0.20	.20000	0.20	.	.	.	0.20	0.20	0.20	0.20	0.20
34	1994	FALL	1	0.20	.20000	0.20	.	.	.	0.20	0.20	0.20	0.20	0.20
34	1994	SPRING	2	0.13	.02500	0.24	0.15	0.11	115	0.03	0.03	0.13	0.24	0.24
34	1994	SUMMER	1	0.23	.22500	0.23	.	.	.	0.23	0.23	0.23	0.23	0.23
34	1994	WINTER	1	0.20	.20000	0.20	.	.	.	0.20	0.20	0.20	0.20	0.20
34	1995	FALL	2	0.65	.25000	1.05	0.57	0.40	87	0.25	0.25	0.65	1.05	1.05
34	1995	SPRING	2	0.20	.20000	0.20	0.00	0.00	0	0.20	0.20	0.20	0.20	0.20
34	1995	SUMMER	2	0.12	.02500	0.21	0.13	0.09	111	0.03	0.03	0.12	0.21	0.21
34	1995	WINTER	2	0.18	.16500	0.20	0.02	0.02	14	0.17	0.17	0.18	0.20	0.20
34	1996	SPRING	4	0.52	.20000	0.91	0.35	0.17	67	0.20	0.23	0.48	0.81	0.91
34	1996	SUMMER	2	0.27	.24000	0.30	0.04	0.03	16	0.24	0.24	0.27	0.30	0.30
34	1996	WINTER	3	0.30	.15000	0.45	0.15	0.09	50	0.15	0.15	0.30	0.45	0.45
34	1997	WINTER	1	0.12	.12000	0.12	.	.	.	0.12	0.12	0.12	0.12	0.12
73	1990	FALL	6	0.94	.41910	1.35	0.32	0.13	34	0.42	0.76	1.00	1.09	1.35
73	1990	SPRING	7	0.63	.15240	1.42	0.48	0.18	75	0.15	0.34	0.41	1.19	1.42
73	1990	SUMMER	7	0.86	.45720	1.17	0.27	0.10	31	0.46	0.66	0.97	1.14	1.17
73	1990	WINTER	7	0.94	.30480	1.37	0.36	0.14	38	0.30	0.69	0.97	1.19	1.37

Aggregate Nutrient Ecoregion: X
Lakes and Reservoirs
Descriptive Statistics by Subecoregion, Year and Season
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SECCHI_m

subecoregion	year	season	N	MEAN	MIN	MAX	STDDEV	STDERR	CV	P5	P25	MEDIAN	P75	P95
73	1991	FALL	5	0.41	.24130	0.74	0.19	0.09	47	0.24	0.33	0.36	0.38	0.74
73	1991	SPRING	13	0.61	.07620	1.14	0.32	0.09	52	0.08	0.41	0.51	0.86	1.14
73	1991	SUMMER	13	0.45	.10160	0.66	0.16	0.05	37	0.10	0.30	0.46	0.58	0.66
73	1991	WINTER	3	0.58	.44450	0.75	0.16	0.09	27	0.44	0.44	0.53	0.75	0.75
73	1992	FALL	2	0.52	.50800	0.53	0.02	0.01	3	0.51	0.51	0.52	0.53	0.53
73	1992	SPRING	11	0.49	.15240	0.76	0.18	0.06	38	0.15	0.32	0.53	0.66	0.76
73	1992	SUMMER	8	0.78	.15240	1.78	0.58	0.21	75	0.15	0.37	0.50	1.27	1.78
73	1992	WINTER	11	0.84	.10160	2.39	0.70	0.21	83	0.10	0.41	0.56	1.07	2.39
73	1993	FALL	9	0.82	.22860	2.79	0.86	0.29	105	0.23	0.30	0.51	0.71	2.79
73	1993	SPRING	8	0.40	.07620	0.69	0.21	0.07	51	0.08	0.27	0.41	0.56	0.69
73	1993	SUMMER	8	0.74	.16510	1.47	0.50	0.18	67	0.17	0.41	0.50	1.24	1.47
73	1993	WINTER	8	0.58	.10160	1.17	0.35	0.12	60	0.10	0.29	0.58	0.80	1.17
73	1994	FALL	9	0.54	.12700	1.68	0.47	0.16	87	0.13	0.28	0.43	0.48	1.68
73	1994	SPRING	9	0.70	.10160	1.83	0.50	0.17	70	0.10	0.39	0.66	0.79	1.83
73	1994	SUMMER	9	0.76	.10160	1.68	0.64	0.21	84	0.10	0.33	0.41	1.50	1.68
73	1994	WINTER	8	0.49	.07620	1.30	0.36	0.13	73	0.08	0.33	0.41	0.53	1.30
73	1995	FALL	9	0.66	.20320	2.21	0.61	0.20	93	0.20	0.33	0.51	0.58	2.21
73	1995	SPRING	8	0.42	.07620	0.88	0.26	0.09	62	0.08	0.20	0.45	0.57	0.88
73	1995	SUMMER	8	0.43	.08890	0.58	0.17	0.06	39	0.09	0.33	0.49	0.55	0.58
73	1995	WINTER	8	0.53	.10160	2.06	0.63	0.22	119	0.10	0.25	0.32	0.46	2.06
73	1996	FALL	9	0.76	.25400	1.47	0.47	0.16	62	0.25	0.33	0.79	0.97	1.47
73	1996	SPRING	10	0.52	.12700	1.42	0.39	0.12	76	0.13	0.28	0.32	0.66	1.42
73	1996	SUMMER	9	0.58	.20320	1.12	0.31	0.10	54	0.20	0.33	0.46	0.81	1.12
73	1996	WINTER	9	0.49	.20320	1.12	0.33	0.11	68	0.20	0.20	0.41	0.71	1.12
73	1997	FALL	11	0.74	.25400	2.67	0.71	0.21	96	0.25	0.28	0.41	0.89	2.67
73	1997	SPRING	13	0.49	.10160	1.07	0.32	0.09	66	0.10	0.16	0.51	0.66	1.07
73	1997	SUMMER	13	0.65	.07620	1.63	0.48	0.13	75	0.08	0.33	0.56	0.71	1.63
73	1997	WINTER	10	0.65	.17780	2.13	0.57	0.18	87	0.18	0.25	0.56	0.71	2.13
73	1998	SPRING	7	0.27	.07620	0.51	0.16	0.06	61	0.08	0.13	0.25	0.46	0.51
73	1998	WINTER	9	0.72	.07620	1.61	0.53	0.18	74	0.08	0.33	0.57	1.07	1.61

Aggregate Nutrient Ecoregion: X
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Descriptive Statistics by Subecoregion, Year and Season
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Total_Phosphorus_ug_L

subecoregion	year	season	N	MEAN	MIN	MAX	STDDEV	STDERR	CV	P5	P25	MEDIAN	P75	P95
34	1990	FALL	2	147.50	80.000	215.00	95.46	67.50	65	80.00	80.00	147.50	215.00	215.00
34	1990	SPRING	2	122.50	120.00	125.00	3.54	2.50	3	120.00	120.00	122.50	125.00	125.00
34	1990	SUMMER	2	122.50	95.000	150.00	38.89	27.50	32	95.00	95.00	122.50	150.00	150.00
34	1990	WINTER	1	90.00	90.000	90.00	.	.	.	90.00	90.00	90.00	90.00	90.00
34	1991	FALL	3	386.67	150.00	830.00	384.23	221.84	99	150.00	150.00	180.00	830.00	830.00
34	1991	SPRING	3	185.00	130.00	230.00	50.74	29.30	27	130.00	130.00	195.00	230.00	230.00
34	1991	SUMMER	3	148.33	90.000	180.00	50.58	29.20	34	90.00	90.00	175.00	180.00	180.00
34	1991	WINTER	2	130.00	90.000	170.00	56.57	40.00	44	90.00	90.00	130.00	170.00	170.00
34	1992	FALL	3	183.33	150.00	250.00	57.74	33.33	31	150.00	150.00	150.00	250.00	250.00
34	1992	SPRING	4	160.00	70.000	280.00	88.32	44.16	55	70.00	100.00	145.00	220.00	280.00
34	1992	SUMMER	3	108.33	100.00	120.00	10.41	6.01	10	100.00	100.00	105.00	120.00	120.00
34	1992	WINTER	2	135.00	120.00	150.00	21.21	15.00	16	120.00	120.00	135.00	150.00	150.00
34	1993	FALL	3	426.67	50.000	1000.00	504.61	291.34	118	50.00	50.00	230.00	1000.0	1000.0
34	1993	SPRING	2	265.00	110.00	420.00	219.20	155.00	83	110.00	110.00	265.00	420.00	420.00
34	1993	SUMMER	1	105.00	105.00	105.00	.	.	.	105.00	105.00	105.00	105.00	105.00
34	1993	WINTER	1	95.00	95.000	95.00	.	.	.	95.00	95.00	95.00	95.00	95.00
34	1994	FALL	2	325.00	210.00	440.00	162.63	115.00	50	210.00	210.00	325.00	440.00	440.00
34	1994	SPRING	2	246.25	2.5000	490.00	344.71	243.75	140	2.50	2.50	246.25	490.00	490.00
34	1994	SUMMER	2	130.00	120.00	140.00	14.14	10.00	11	120.00	120.00	130.00	140.00	140.00
34	1994	WINTER	1	21.25	21.250	21.25	.	.	.	21.25	21.25	21.25	21.25	21.25
34	1995	FALL	3	136.67	50.000	260.00	109.70	63.33	80	50.00	50.00	100.00	260.00	260.00
34	1995	SPRING	2	190.00	140.00	240.00	70.71	50.00	37	140.00	140.00	190.00	240.00	240.00
34	1995	SUMMER	2	175.63	71.250	280.00	147.61	104.38	84	71.25	71.25	175.63	280.00	280.00
34	1995	WINTER	2	182.50	125.00	240.00	81.32	57.50	45	125.00	125.00	182.50	240.00	240.00
34	1996	SPRING	3	136.67	60.000	260.00	107.86	62.27	79	60.00	60.00	90.00	260.00	260.00
34	1996	SUMMER	2	320.00	80.000	560.00	339.41	240.00	106	80.00	80.00	320.00	560.00	560.00
34	1996	WINTER	1	150.00	150.00	150.00	.	.	.	150.00	150.00	150.00	150.00	150.00
34	1997	FALL	1	230.00	230.00	230.00	.	.	.	230.00	230.00	230.00	230.00	230.00
34	1997	SPRING	1	190.00	190.00	190.00	.	.	.	190.00	190.00	190.00	190.00	190.00
34	1997	SUMMER	1	75.00	75.000	75.00	.	.	.	75.00	75.00	75.00	75.00	75.00
34	1997	WINTER	1	270.00	270.00	270.00	.	.	.	270.00	270.00	270.00	270.00	270.00
34	1998	WINTER	1	70.00	70.000	70.00	.	.	.	70.00	70.00	70.00	70.00	70.00

Aggregate Nutrient Ecoregion: X
Lakes and Reservoirs
Descriptive Statistics by Subecoregion, Year and Season
from 1990 to 1998
Total_Phosphorus_ug_L

subecoregion	year	season	N	MEAN	MIN	MAX	STDDEV	STDERR	CV	P5	P25	MEDIAN	P75	P95
73	1990	FALL	10	110.50	30.000	240.00	75.92	24.01	69	30.00	30.00	120.00	175.00	240.00
73	1990	SPRING	14	131.25	2.5000	400.00	118.57	31.69	90	2.50	45.00	80.00	200.00	400.00
73	1990	SUMMER	10	119.00	30.000	320.00	106.40	33.65	89	30.00	35.00	67.50	165.00	320.00
73	1990	WINTER	10	90.00	50.000	165.00	41.83	13.23	46	50.00	50.00	77.50	120.00	165.00
73	1991	FALL	5	155.00	35.000	270.00	89.58	40.06	58	35.00	120.00	140.00	210.00	270.00
73	1991	SPRING	15	119.75	40.000	330.00	81.78	21.12	68	40.00	70.00	80.00	175.00	330.00
73	1991	SUMMER	15	168.08	30.000	325.00	82.74	21.36	49	30.00	95.00	171.25	230.00	325.00
73	1991	WINTER	3	88.33	75.000	110.00	18.93	10.93	21	75.00	75.00	80.00	110.00	110.00
73	1992	FALL	6	222.71	31.250	670.00	230.09	93.93	103	31.25	95.00	155.00	230.00	670.00
73	1992	SPRING	14	103.57	30.000	220.00	63.20	16.89	61	30.00	50.00	80.00	150.00	220.00
73	1992	SUMMER	14	150.71	25.000	370.00	103.98	27.79	69	25.00	40.00	152.50	210.00	370.00
73	1992	WINTER	14	108.57	40.000	310.00	78.04	20.86	72	40.00	55.00	80.00	140.00	310.00
73	1993	FALL	18	106.11	20.000	320.00	82.74	19.50	78	20.00	40.00	92.50	160.00	320.00
73	1993	SPRING	11	102.73	45.000	290.00	72.85	21.96	71	45.00	50.00	80.00	115.00	290.00
73	1993	SUMMER	14	128.21	30.000	260.00	76.02	20.32	59	30.00	50.00	117.50	190.00	260.00
73	1993	WINTER	14	90.45	11.250	270.00	70.15	18.75	78	11.25	40.00	70.00	120.00	270.00
73	1994	FALL	14	114.29	50.000	245.00	53.78	14.37	47	50.00	70.00	122.50	140.00	245.00
73	1994	SPRING	17	113.38	2.5000	360.00	94.07	22.82	83	2.50	30.00	105.00	140.00	360.00
73	1994	SUMMER	34	173.24	30.000	1115.00	183.61	31.49	106	45.00	90.00	125.00	220.00	310.00
73	1994	WINTER	14	162.77	30.000	566.25	171.79	45.91	106	30.00	60.00	85.00	210.00	566.25
73	1995	FALL	11	115.00	40.000	225.00	62.13	18.73	54	40.00	60.00	100.00	170.00	225.00
73	1995	SPRING	14	127.86	55.000	290.00	74.62	19.94	58	55.00	75.00	95.00	190.00	290.00
73	1995	SUMMER	11	149.66	31.250	410.00	111.99	33.77	75	31.25	50.00	130.00	180.00	410.00
73	1995	WINTER	14	90.00	2.5000	220.00	67.70	18.09	75	2.50	40.00	85.00	110.00	220.00
73	1996	FALL	11	117.73	55.000	270.00	69.55	20.97	59	55.00	70.00	90.00	130.00	270.00
73	1996	SPRING	16	50.00	5.0000	135.00	46.58	11.65	93	5.00	12.50	40.00	75.00	135.00
73	1996	SUMMER	12	99.17	35.000	205.00	50.62	14.61	51	35.00	75.00	87.50	120.00	205.00
73	1996	WINTER	11	139.09	50.000	490.00	123.73	37.31	89	50.00	70.00	100.00	160.00	490.00
73	1997	FALL	12	133.75	10.000	360.00	102.27	29.52	76	10.00	77.50	115.00	185.00	360.00
73	1997	SPRING	18	138.89	30.000	460.00	107.63	25.37	77	30.00	80.00	97.50	170.00	460.00
73	1997	SUMMER	16	175.00	60.000	460.00	114.50	28.62	65	60.00	75.00	160.00	232.50	460.00
73	1997	WINTER	12	100.00	30.000	160.00	39.77	11.48	40	30.00	75.00	95.00	135.00	160.00

Aggregate Nutrient Ecoregion: X
Lakes and Reservoirs
Descriptive Statistics by Subecoregion, Year and Season
from 1990 to 1998
Total_Phosphorus_ug_L

subecoregion	year	season	N	MEAN	MIN	MAX	STDDEV	STDERR	CV	P5	P25	MEDIAN	P75	P95
73	1998	SPRING	7	145.71	60.000	310.00	95.19	35.98	65	60.00	60.00	120.00	240.00	310.00
73	1998	WINTER	11	96.36	50.000	150.00	27.58	8.31	29	50.00	80.00	90.00	120.00	150.00

APPENDIX C

Quality Control/Quality Assurance Rules

Continued Support for the Compilation and Analysis of National Nutrient Data

3 Nutrient Ecoregion/Waterbody Type Summary Chapters

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CONTENTS

1.0 BACKGROUND

The Nutrient Criteria Program initiated the development of a national Nutrient Criteria Database application that is used to store and analyze nutrient data. The ultimate use of these data is to derive ecoregion specific nutrient criteria. EPA converted STOrage and RETrieval (STORET) legacy data, National Stream Quality Accounting Network (NASQAN) data, National Water-Quality Assessment (NAWQA) data, and other relevant nutrient data from universities and States/Tribes into the database. The data imported into the Nutrient Criteria Database are used to develop national nutrient criteria recommendations.

1.1 Purpose

The purpose of this deliverable is to provide EPA with information regarding the database used to create the statistical reports which will be used to derive ecoregion-specific nutrient criteria for Level III ecoregions. There are fourteen aggregate nutrient ecoregions. Each aggregate nutrient ecoregion is divided into smaller ecoregions (subecoregions) referred to as Level III ecoregions. EPA will determine criteria for the waterbody types and Level III ecoregions within the following aggregate nutrient ecoregions:

- Lakes and Reservoirs
  - Aggregate Nutrient ecoregions: 3, 4, 5, and 14

- Rivers and Streams
  - Aggregate Nutrient ecoregions: 1, 4, 5, 8, and 10

1.2 References

This section lists documents that contain baselines, standards, guidelines, policies, and references that apply to the data analysis. Listed editions were valid at the time of publication. All documents are subject to revision, but these specific editions govern the concepts described in this document.

Nutrient Criteria Technical Guidance Document: Lakes and Reservoirs (Draft). EPA, Office of Water, EPA 822-D-99-001, April 1999.

Nutrient Criteria Technical Guidance Manual: Rivers and Streams (Draft). EPA, Office of Water, EPA 822-D-99-003, September 1999.

Guidance for Data Quality Assessment: Practical Methods for Data Analysis. EPA, Office of Research and Development, EPA QA/G-9, January 1998.

2.0 QA/QC PROCEDURES

In order to develop nutrient criteria, EPA needed to obtain nutrient data from the states. EPA requested nutrient data from the states and forwarded the data sets to INDUS via e-mail and/or US mail. In addition, EPA tasked INDUS to convert data from three national data sets. EPA provided INDUS with a Legacy STORET extraction to convert into the database. The United States Geologic Survey (USGS) sent INDUS a CD-ROM with NASQAN data to convert. INDUS downloaded NAWQA files from the USGS Web site to convert the data. In total, INDUS converted and imported the following national and state data sets into the Nutrient Criteria Database:

- Legacy STORET
- NAWQA
- NASQAN
- EPA Region 1
- EPA Region 2 - Lake Champlain Monitoring Project
- EPA Region 2 - NYSDEC Finger Lakes Monitoring Program
- EPA Region 2 - NY Citizens Lake Assessment Program
- EPA Region 2 - Lake Classification and Inventory Survey
- EPA Region 2 - NYCDEP (1990-1998)
- EPA Region 2 - NYCDEP (Storm Event data)
- EPA Region 2 - New Jersey Nutrient Data (Tidal Waters)
- EPA Region 5
- EPA Region 3
- EPA Region 3 - Nitrite Data
- EPA Region 3 - Choptank River files
- EPA Region 4 - Tennessee Valley Authority
- EPA Region 7 - Central Plains Center for BioAssessment (CPCB)
- EPA Region 7 - REMAP
- EPA Region 2 - Delaware River Basin Commission (1990-1998)
- EPA Region 3 - PA Lake Data
- EPA Region 3 - University of Delaware
- EPA Region 10
- University of Auburn
- EPA Region 8 - MT and WY
- EPA Region 9
- Suffolk County
- NYCDEC
- NY Lakes Morphometry
- EPA Region 8 - South Dakota
- EPA Region 8 - Colorado Reservoir
- EPA Region 4
- EPA Region 10 - Lake Data

- EPA Region 7 - Central Plains Center for BioAssessment (CPCB) 2
- EPA Region 8 - North Dakota
- EPA Region 8 - Eagle River
- EPA Region 8 - Utah
- Florida

As part of the conversion process, INDUS performed a number of Quality Assurance/Quality Control (QA/QC) steps to ensure that the data were properly converted into the Nutrient Criteria Database. Sections 2.1 and 2.2 explain the steps performed by INDUS to convert the data.

2.1 National Data Sets

INDUS converted three national data sets into the Nutrient Criteria Database: Legacy STORET data, NASQAN data, and NAWQA data. A previous EPA contractor performed the extraction of Legacy STORET data and documented the QA/QC procedures used on the data. This documentation is included in Appendix A. INDUS performed minimal QA/QC on the Legacy STORET data set because the previous contractor completed the steps outlined in Appendix A. INDUS and EPA also agreed to convert the NAWQA and NASQAN data sets with minimal QA/QC on the assumption that the source agency, the USGS, QA/QC'd the data.

For each of the three national data sets, INDUS ran queries to determine if 1) samples existed without results and 2) if stations existed without samples. Per Task Order Project Officer (TOPO) direction, these records were deleted from the system. For analysis purposes, EPA determined that there was no need to keep station records with no samples and sample records with no results. INDUS also confirmed that each data set contained no duplicate records.

In addition, INDUS deleted all composite results from the Legacy STORET data. Per TOPO direction, it was decided that composite sample results would not be used in the statistical analysis.

2.2 State Data

Each state data set was delivered in a unique format. Many of the data sets were delivered to INDUS without corresponding documentation. INDUS analyzed each state data set in order to determine which parameters should be converted for analysis. INDUS obtained a master parameter table from EPA and converted the parameters in the state data sets according to those that were present in the EPA parameter table. INDUS converted all of the data elements in the state data sets that mapped directly to the Nutrient Criteria Database; data elements that did not map to the Nutrient Criteria Database were not converted. In some cases, state data elements that did not directly map into the Oracle database were inserted into a comment field within the database. Also, INDUS maintained an internal record of which state data elements were inserted into the comment field.

As part of the data clean-up efforts, INDUS determined whether or not there were any duplicate records in the state data sets and deleted the duplicate records. INDUS checked the waterbody, station, and sample entities for duplicate records. However, if there was not enough information provided to determine duplicates such as sampling date, there was no way for INDUS to locate duplicate records. In addition, INDUS deleted station records with no samples and sample records with no results. INDUS also deleted waterbody records that were not associated with a station. In each case, INDUS maintained an internal record of how many records were deleted.

If INDUS encountered referential integrity errors, such as samples that referred to stations that did not exist, or if INDUS was unsure of whether a record was a duplicate, INDUS contacted the agency directly via e-mail or phone to resolve any issues that arose. INDUS saved an electronic copy of each e-mail correspondence with the states to ensure that a record of the decision was maintained.

Finally, INDUS examined the remark codes of each result record in the state data sets. INDUS mapped the remark codes to the STORET remark codes listed in Table 2 of Appendix A. If any of the state result records were associated with remark codes marked as "Delete" in Table 2 of Appendix A, the result records were not converted into the database.

2.3 Laboratory Methods

Many of the state data sets did not contain laboratory method information. In addition, laboratory method information was not available for the three national data sets. In order to determine missing laboratory method information, EPA tasked another contractor to contact the data owners to obtain the laboratory method. In some cases, the data owners responded and the laboratory methods were added to the database. In other cases, the methods are unknown.

2.4 Waterbody Name and Class Information

A large percentage of the data did not have waterbody-specific information. The only waterbody information contained in the three national data sets was the waterbody name, which was embedded in the station 'location description' field. Most of the state data sets contained waterbody name information; however, much of the data were duplicated throughout the data sets. Therefore, the waterbody information was cleaned manually. For the three national data sets, the 'location description' field was extracted from the station table and moved to a temporary table. The 'location description' field was sorted alphabetically. Unique waterbodies were grouped together based on name similarity and whether or not the waterbodies fell within the same county, state, and waterbody type. Finally, the 'location description' field was edited to include only waterbody name information, not descriptive information. For example, 110 MILE CREEK AT POMONA DAM OUTFLOW, KS PO-2 was edited to 110 MILE CREEK. Also, if 100 MILE CREEK was listed ten times in New York, but in four different counties, four 100 MILE CREEK waterbody records were created.

Similar steps were taken to eliminate duplicate waterbody records in the state data sets. If a number of records had similar waterbody names and fell within the same state, county, and waterbody type, the records were grouped to create a unique waterbody record.

Most of the waterbody data did not contain depth, surface area, and volume measurements. EPA needed this information to classify waterbody types. EPA attempted to obtain waterbody class information from the states. EPA sent waterbody files to the regional coordinators and requested that certain class information be completed by each state. The state response was poor; therefore, EPA was not able to perform statistical analysis for the waterbody types by class.

2.5 Ecoregion Data

Aggregate nutrient ecoregions and Level III ecoregions were added to the database using the station latitude and longitude coordinates, the county centroid, or HUC (Hydrological Unit Code) centroid. If a station was lacking latitude and longitude coordinates and county information, the data were not included in the statistical analysis. Appendix B lists the steps taken to add the two ecoregion types (aggregate and Level III) to the Nutrient Criteria Database. The ecoregion names were pulled from aggregate nutrient ecoregion and Level III ecoregion Geographical Information System (GIS) coverages. In summary, the station latitude and longitude coordinates were used to determine the ecoregion under the following circumstances:

- The latitude and longitude coordinates fell within the county/state listed in the station table.
- The county data were missing.

The county centroid was used to determine the ecoregions under the following circumstances:

- The latitude and longitude coordinates were missing, but the state/county information was available.
- The latitude and longitude coordinates fell outside the county/state/HUC listed in the station table. The county information was assumed to be correct; therefore, the county centroid was used.

The HUC centroid was used to determine the ecoregions under the following circumstances:

- The latitude and longitude coordinates and county were missing, but the HUC information was available.

If the latitude and longitude coordinates fell outside the continental US county coverage file (i.e., the point fell in the ocean or Mexico/Canada), the nearest ecoregion was assigned to the station.

3.0 STATISTICAL ANALYSIS REPORTS

Aggregate nutrient ecoregion tables were created by extracting all observations for a specific aggregate nutrient ecoregion from the Nutrient Criteria Database. Then, the data were reduced to create tables containing only the yearly median values. To create these tables, the median value for each waterbody was calculated using all observations for each waterbody by Level III ecoregion, state, county, year, and season. Tables of decade median values were created from the yearly median tables by calculating the median for each waterbody by Level III ecoregion, state, county, decade and season.

The Data Source and the Remark Code reports were created using all observations (all reported values). All the other reports were created from either the yearly median tables or the decade median tables. In other words, the descriptive statistics and regressions were run using the median values for each waterbody and not the individual reported values.

Statistical analyses were performed under the assumption that this data set is a random sample. If this assumption cannot be verified, the observations may or may not be valid. Values below the 1st and 99th percentile were removed from the Legacy STORET database prior to the creation of the national database. Also, data were treated according to the Legacy STORET remark codes in Appendix A.

The following contains a list of each report and the purpose for creating each report:

- Data Source—Created to provide a count of the amount of data and to identify the source(s).
- Remark Codes—Created to provide a description of the data.
- Median of Each Waterbody by Year—This was an intermediate step performed to obtain a median value for each waterbody to be used in the yearly descriptive statistics reports and the regression models.
- Median of Each Waterbody by Decade—This was an intermediate step performed to obtain a median value for each waterbody to be used in the decade descriptive statistics.
- Descriptive Statistics—Created to provide EPA with the desired statistics for setting criteria levels.
- Regression Models—Created to examine the relationships between biological and nutrient variables.

Note: Separate reports were created for each season.

3.1 Data Source Reports

Data source reports were presented in the following formats:

- The number and percentage of data from each data source were summarized in tables for each aggregate nutrient ecoregion by season and waterbody type.

- The number and percentage of data from each data source were summarized in tables for each aggregate nutrient ecoregion for all seasons and waterbody type.

- The number and percentage of data from each data source were summarized in tables for each Level III ecoregion by season and waterbody type.

The 'Frequency' represents the number of data values from a specific data source for each parameter by data source. The 'Row Pct' represents the percentage of data from a specific data source for each parameter.

3.2 Remark Code Reports

Remark code reports were presented in the following formats:

- The number and percentage of data associated with a particular remark code for each parameter were summarized in tables by Level III ecoregion by decade and season.
- The number and percentage of data associated with a particular remark code for each parameter were summarized in tables by Level III ecoregion by year and season.

The 'Frequency' represents the number of data values corresponding to the remark code in the column. The 'Row Pct' represents the percentage of data that was associated with the remark code in that row.

In the database, remark codes that were entered by the states were mapped to Legacy STORET remark codes. Prior to the analysis, the data were treated according to these remark codes. For example, if the remark code was 'K,' then the reported value was divided by two. Appendix A contains a complete list of Legacy STORET remark codes.

Note: For the reports, a remark code of 'Z' indicates that no remark codes were recorded. It does not correspond to Legacy STORET code 'Z.'

3.3 Median of Each Waterbody

To reduce the data and to ensure heavily sampled waterbodies or years were not over represented in the analysis, median value tables (described above) were created. The yearly median tables and decade median tables were delivered to the EPA in electronic format as csv (comma separated value or comma delimited) files.

3.4 Descriptive Statistic Reports

The number of waterbodies, median, mean, minimum, maximum, 5th, 25th , 75th , 95th percentiles, standard deviation, standard error, and coefficient of variation were calculated. The tables (described above) containing the decade median values for each waterbody for each parameter were used to create descriptive statistics reports for:

- Level III ecoregions by decade and season
- Aggregate nutrient ecoregions by decade and season

In addition, the tables containing the yearly median values for each waterbody for each parameter were used to create descriptive statistics reports for:

- Level III ecoregions by year and season

3.5 Regression Models

Simple linear regressions using the least squares method were performed to examine the relationships between biological and nutrient variables in lakes and reservoirs, and rivers and streams. Regressions were performed using the yearly median tables. Chlorophyll(s) in micrograms per liter (ug/L), Secchi in meters (m), Dissolved Oxygen in milligrams per liter (mg/L), Turbidity, and pH were the biological variables in these models. Secchi data were used in the lake and reservoir models, and Turbidity data were used in the river and stream models. The nutrient variables in these models include: Total Phosphorus in ug/L, Total Nitrogen in mg/L, Total Kjeldahl Nitrogen in mg/L, and Nitrate and Nitrite in mg/L.

4.0 TIME PERIOD

Data collected from January 1990 to December 2000 were used in the statistical analysis reports. To capture seasonal differences, the data were classified as follows:

- Aggregate nutrient ecoregions: 6, 7, and 8

1.05	Spring:	April to May
1.6	Summer:	June to August

- ★ Fall: September to October
- ★ Winter: November to March

- Aggregate nutrient ecoregions: 1, 2, 3, 4, 5, 9, 10, 11, 12, 13, and 14

  - Spring: March to May
  - Summer: June to August
  - Fall: September to November
  - Winter: December to February

5.0 DATA SOURCES AND PARAMETERS FOR THE AGGREGATE NUTRIENT ECOREGIONS

This section provides information for the nutrient aggregate ecoregions that were analyzed by waterbody type. Each section lists the data sources for the aggregate nutrient ecoregion including: 1) the data sources, 2) the parameters included in the analysis, and 3) the Level III ecoregions within the aggregate nutrient ecoregions.

Note: For analysis purposes, data for the following parameters were grouped together and reported under Phosphorous, Dissolved Inorganic (DIP):

Phosphorus, Dissolved Inorganic (DIP)
Phosphorus, Dissolved (DP)
Phosphorus, Dissolved Reactive (DRP)
Orthophosphate, dissolved, mg/L as P
Orthophosphate (OPO4_PO4)

5.1 Lakes and Reservoirs

5.1.1 Aggregate Nutrient Ecoregion 1

<u>Data Sources:</u>

Legacy STORET
EPA Region 10

<u>Parameters:</u>

Chlorophyll A, Fluorometric, corrected (ug/L)
Dissolved Oxygen (DO) (mg/L)
Nitrite and Nitrate, (NO2+NO3) (mg/L)
Nitrogen, Total Kjeldhal (TKN) (mg/L)
Phosphorus, Total (TP) (ug/L)

SECCHI (m)
pH

Level III ecoregions:

3

5.1.2 Aggregate Nutrient Ecoregion 10

Data Sources:

Legacy STORET

Parameters:
Chlorophyll A, Flourometric, corrected (µg/L)
Chlorophyll A, Phytoplankton, spectrophotometric Acid (ug/L)
Chlorophyll A, Trichromatic, uncorrected (ug/L)
Dissolved Oxygen (DO) (mg/L)
Nitrite and Nitrate, (NO2+NO3) (mg/L)
Nitrogen, Total (TN) (mg/L)
Nitrogen, Total Kjeldhal (TKN) (mg/L)
Phosphorus, Total (TP) (ug/L)
SECCHI (m)

Level III ecoregions:

34, 73

5.2 Rivers and Streams

5.2.1 Aggregate Nutrient Ecoregion 13

Data sources:

Florida
Legacy STORET
NASQAN

Parameters:

Chlorophyll A, Phytoplankton, spectrophotometric Acid (ug/L)
Dissolved Inorganic Phosphorus (DIP) (ug/L)

Dissolved Oxygen (% Saturated)
Dissolved Oxygen (DO) (mg/L)
Nitrite and Nitrate, (NO2+NO3) (mg/L)
Nitrogen, Total (TN) (mg/L)
Nitrogen, Total Kjeldhal (TKN) (mg/L)
Phosphorus, Total (TP) (ug/L)
Phosphorus, orthophosphate, total, as P(ug/L)
Turbidity (FTU)
Turbidity (NTU)
Turbidity (JCU)
pH